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# SAMPLING AND DETERMINATION OF MINIMUM AMOUNTS OF LEAD IN THE ATMOSPHERE

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# SAMPLING AND DETERMINATION OF MINIMUM AMOUNTS OF LEAD IN THE ATMOSPHERE

[Probenahme und Bestimmung Kleinster Bleimengen in der Luft]

by

A. Heller and H. Kettner

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## 1. INTRODUCTION

Originally, the research project "Sampling and determination of minimum amounts of lead in the atmosphere" was supposed to have been carried out in close cooperation with the State Industrial Physician for Westphalia, Dr. BUCHUR, Bochum, who was at that time assigned the research problem "Determination of the effect of lead on the human organism". However, it very soon proved expedient to deal separately with the research projects due to the fact that knowledge of the effect on health could not be gained in the open air on account of too low concentrations, but only in lead processing plants. Here, however, lead concentrations are so high that their exact determination offers no difficulty, whereas it was very problematical at the beginning of the investigation with regards to the extremely low concentrations in the open. We wish to express our thanks for the financial support of this research project to the Prime Minister - Regional Office for Research - Nordheim-Westphalia as well as to the Group Research of the VDI commission "Reinhaltung der Luft".

## 2. OCCURRENCE OF LEAD IN THE ATMOSPHERE

Lead is no natural ingredient of the atmosphere, even though it is sometimes designated as "ubiquitous substance". Lead was probably called that because it is contained in practically all solid minerals. Locally, lead contamination can occur due to whirling-up of lead-containing dust in the vicinity of deposits. Formerly, considerable amounts of lead occurred in the vicinity of lead-emitting plants such as lead refineries and others. Lead emitted from furnaces is wide-spread, though in low concentrations, due to the fact that in general all fossil fuels contain a certain, although

slight amount of lead. The lead content of the air, which is significant today from a hygienic standpoint, originates from automobile traffic. The lead compounds added to gasoline for increasing antiknocking properties, such as tetraethyl, tetramethyl lead, lead chloride and lead bromide, are converted to lead oxide under the influence of oxygen and the very high temperatures prevailing in the combustion engine, and enter the atmosphere as such. "Atmospheric lead is a finely dispersed, solid aerosol.

## 3. SAMPLING

At present, only discontinuous methods come in question for sampling suspended dust for determining the lead in the atmosphere. They are characterized by the substance to be determined accumulating in a medium or on a filter. The kind of sampling is determined by a series of reciprocally acting factors.

### 3.1 DURATION OF SAMPLING (MEASURING TIME INTERVAL)

With discontinuous sampling, variations in time can only be covered to the extent permitted by the duration of the sampling. In order to cover the greatest possible number of variations in the course of the day it is necessary to keep the duration of sampling as short as possible. However there are limits to this requirement due to the fact that a certain minimum quantity of lead is required for an analytical determination. Other considerations, such as expenditure of time for analyses to be conducted, effect on humans and animals etc, also make it appear advisable to maintain a definite time interval for measurements. Thirty minutes have proven a suitable time interval for measurements on gaseous substances; it is also used for MIK values. However, this standard does not apply to dust.

The accumulated amount of lead depends on the lead content of the atmosphere and the throughput of air of the sampling device. The lead content in large cities various from about .1 µg/m³ to 10 µg/m³ and more. Assuming that at least 5 µg of lead are required for an analytical determination, in the two noted cases this amount would be contained in the atmosphere at a content of .1 µg/m³ in 50 m³ of air, but already at a content of 10 µg/m³ in .5 m³ of air. Obtaining 5 µg of lead within 30 minutes would be possible with high lead concentrations e.g. with impingers (air throughput of 1.5 m³/h), but not with low ones; only instruments with high throughput of air come in question for these concentrations. Discussions on the duration of sampling in the VDI committees "MIK Lead", "MIK Suspended Dust" and "Determination of the Dust Concentration in the Atmosphere" finally resulted in the proposal to recommend a time duration of one hour for sampling, as this at present best meets the requirements of the measuring technique as well as the medical standpoint. Consequently, the duration of sampling always amounted to one hour. Also of importance was the desire to determine the dust concentration besides the lead content and with it the percentage share of lead in the dust. However, extending the duration of sampling to several hours or even days is quite possible.

## 3.2 SAMPLING DEVICES

The comments under 3.1 make it evident that the samoling device to be used must provide a high degree of air throughput. To the best of our knowledge, at the start of this investigation such devices have been manufactured and used only in the USA. The devices offered by several manufacturers (Staplex, Gelman, Unico) are designated "High Volume Sampler"

and are on the order of rapidly rotating fans of the dust exhauster type, ahead of which a filter in a suitable frame has been inserted (filter holder). Due to the fact that experience in measuring with such a device by the firm of Staplex, New York, was already on hand in the Institute, Staplex devices were used for these studies. The device (see Fig.1) is designed in such a manner that three filter holder of different sizes, 10 cm dia., 22.5 x 15 cm and 20 x 25 cm can be attached. The precipitation surface of the filter is reduced by the frame and amounts to only 9.6 cm dia., 20.5 x 13 cm and 18 x 23 cm. The throughput of air does not only depend on the size of the suction area but also on the porosity of the filter material. Measuring of the throughput of air is effected by means of small rotameters attached to the rear of the device in a bypass calibrated in cfm/min.

Fig.1. Staplex High Volume Sampler with three different filter holders.

The suction force varies from device to device and the difference is not inconsiderable. Under like conditions there were differences in the

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effectiveness of the throughput from minimum to maximum throughput of more than 20%. These different amounts of output of devices that only seem to be alike necessitated checking the devices for indication. This check was performed by means of a pitot tube manufactured by the firm of Hydro-Apparatebau-Anstalt, Düsseldorf. Incidentally, this firm has also been of help with the calculations.

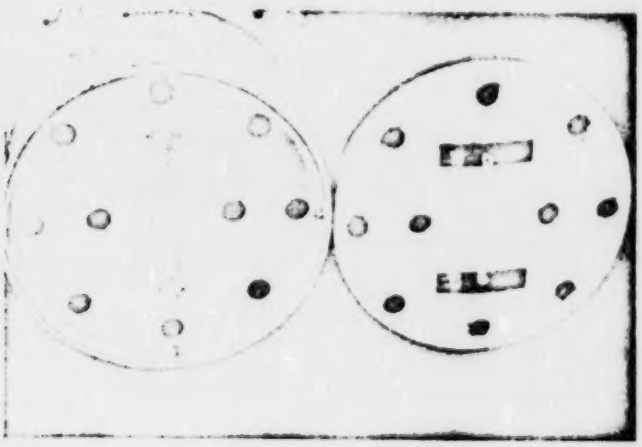

Fig.2. Rear of High Volume Sampler with rotameter

The pitot tube was designed in accordance with DIN 1952 in conformance with data of the expected throughput and the inside diameter of the measuring tube of 70 mm. The measurement itself was performed by interposing another venturi tube simulating the resistance of a 25 x 20 cm fiberglass filter. Deviations compared to the indication were as follows:

Staplex 1 - + 10.3%

Staplex 2 - - 7.2%

Staplex 3 - + 2.2%

Staplex 4 - - 12.4%

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Fig.3. Checking the throughput indication by means of a pitot tube

Device No.4 showed the greatest deviation, where the actual throughput was around 12.4% higher than indicated by the rotameter of the device.

3.3 FILTER

The following should be stated with regards to the choice of filter material: from the standpoint of the analyst the material best suited would be the one bringing the least possible amount of substance to be determined into the analytical process. This requirement is met by pure cellulose filters that can be incinerated without residue. For a simultaneous determination of lead and suspended dust content the following requirements are set on filter fleece:

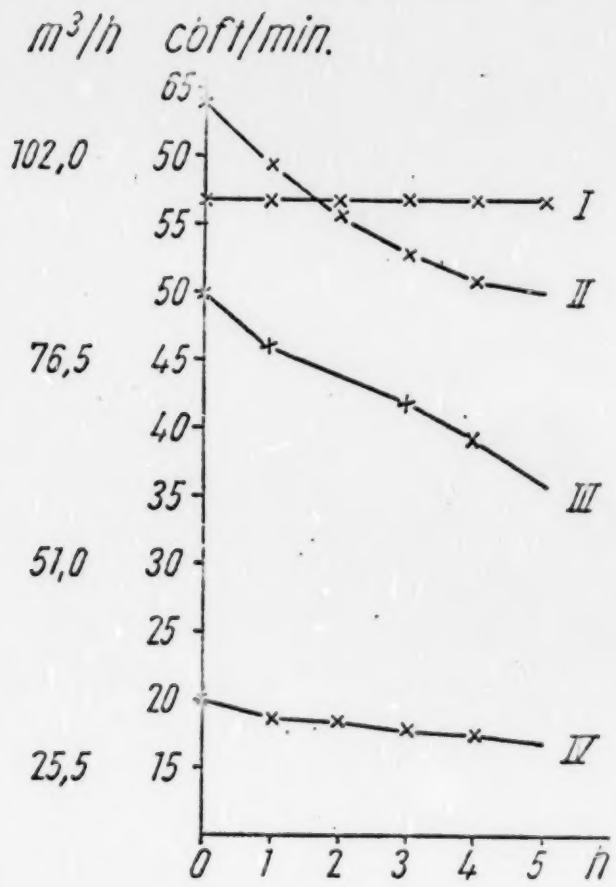


Fig.4. Permeability to air of filters inside of 5 hours
I Fiberglass filter; II Black band filter;
III White band filter; IV Blue band filter

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1. Constant weight,
2. Good mechanical stability, pressure resistance, no abrasion or lint,
3. High permeability to air,
4. High Precipitating capability,
5. Hydrophobia and low swelling property, even with acid reaction,
6. No transmission of substances interfering with analysis, even from bonding agent.

Two types of filters were directly excluded from possible use, the microsorban filter on account of the impossibility to attain constant weight and the membrane filter which exhibited too low a throughput of air.

The first tests for filter suitability were applied to cellulose filters of brands "Black band", "Blue band" and "White band". However, these filters were unsuitable for the job. The main disadvantages of these filters are: difficult to attain constant weight, susceptibility to acids as well as hydrophylia and swelling property. Efficiency of separation was tested qualitatively by means of placing a fiberglass filter underneath; with the black band filter, which is penetrated by fine dust, the backing is shortly colored. No gray coloring could be detected in the backing, but the permeability of the blue band filter to air was so slight that it too was out of the question. White band filters were between black band and blue band filters in efficiency of separation as well as in throughput. The diagram in Fig.4 depicts the behavior of the tested cellulose filters with reference to permeability to air.

Among other things, the decrease in throughput in the course of 5 hours can be learned from the diagram. In contrast to cellulose filters, fiberglass filters (compare 3.31) exhibit no decrease of permeability worth mentioning. In summary, the following can be stated with regards to cellulose filters:

1. Filters that have a high permeability to air, exhibit to low an efficiency of separation and vice versa.
2. The resistance of filters increases considerably with the duration of sampling; this can partly be traced back to covering with dust, but is mainly due to swelling of the material (acid swelling).

3. Constant weight is very difficult to attain and only under especially costly conditions.

3.3 FIBERGLASS FILTERS

Under these circumstances we were obliged to investigate whether other filter material might be suitable for dust separation (and subsequent lead determination). It was known that in the USA fiberglass filters had been used for the determination of lead and other dust ingredients, but that sampling stretched over a 24 hour or longer period. Just at the outset of this investigation a manufacturing company in the Federal Republic of Germany put fiberglass filters on the market which were improved several times in the course of the next months. The first of these glass filters (Schleicher and Schüll No.6 and No.8) gave off lint at the edges and were otherwise mechanically also not very stable, so that they were out of consideration. Fiberglass filters designated No.9 from the same firm half a year later, having an organic bonding agent, proved suitable, as demonstrated by appropriate tests. However, the delivery of a larger quantity on the basis of these preliminary tests proved quite unsatisfactory. A completely different material had been furnished than had been used for the suitability tests. Finally, it was discovered that the manufacturer had in the meantime changed the organic bonding agent with which the fleece was manufactured. While the new filters exhibited a better mechanical stability they gave off so much organic bonding agent during extraction with acid in the analytical process that a lead determination in accordance with the dithizone method, were chloroform is used as solvent, became impossible. The bonding agent formed stable emulsions with the solvent and water, which

did not decompose even after a long period of time. Only a third shipment of fiberglass filters with an organic bonding agent that had in the meantime again been changed in accordance with our wishes, proved satisfactory. However, much time had been lost due to this state of affairs. The three types of filters that already exhibit visual differences are depicted in Fig.5.

The differences in surface that can be seen, also depend on the manufacturing method of the fleece on the paper machine.

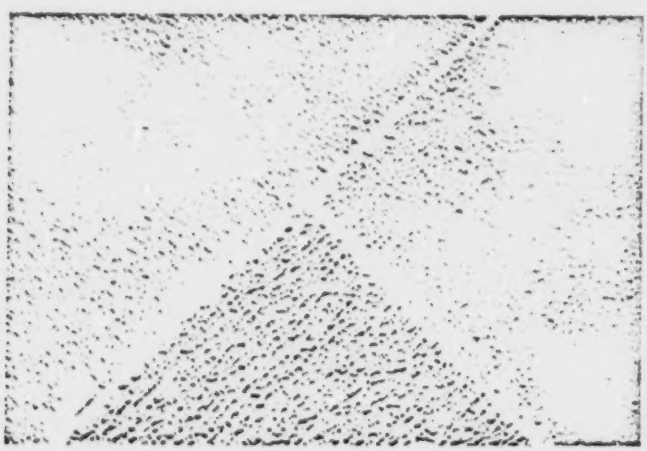


Fig.5. Three different fiberglass filters, bearing one and the same designation, in the state of development.

Irregardless of different surfaces, fiberglass filters with practically the same or similar structure can exhibit far-reaching differences. This is not surprising if their manufacture is more closely scrutinized. The individual processes leading to deviations are mainly as follows:

1. Manufacture of the glass bath from preponderantly mineral, that is,

chemically not pure substances; the composition of the melt, including the gangue, determines in addition to the physical the chemical properties of the fibrils in a decisive way. Due to the fact that mineral substances are subject to considerable variations it is necessary to figure on differences not only from glass works to glass works but also from charge to charge.

2. The manufacture of the glass fiber wool from the smelting flux; it determines above all the thickness of the fibers which can go down to .1 um.

3. The siliconization - this renders the material actually usable for dust separation - makes the fibrils hydrophobic and elastic, but introduces organic material.

4. Manufacture of foils on paper-making machines, using organic or anorganic bonding agents.

5. Burn-up of organic impurities.

6. Cutting the paper to different forms and sizes.

Practically all of these operations contribute to the formation of specific features; it is therefore to be expected that even paper shipments within a short time of one another and having the same marking exhibit different characteristics.

It must furthermore be taken into consideration that the manufacture of fiberglass filters is a young one, barely thirty years old, and that the production processes are even today still in a certain developmental stage. During the qualification test of the third shipment of fiberglass filters No.) (Schleicher and Schüll) another manufacturer of fiberglass filters became known in the Federal Republic of Germany, the firm of Gessner, Ober-

bruckmühl. This firm markets its filters with the designation L 60; according to data from this firm these filters are produced without bonding agents. These sheets have also been included in our tests.

As it had been established that a very high throughput of air would be required for sampling we had from the start turned our attention to filters 20 x 25 cm large and these were used in the majority of determinations.

3.311 WEIGHT OF FIBERGLASS FILTERS AND DEVIATIONS

For the determination of the weight of the filters and their deviations from standard we have in each case taken 10 (sometimes 20) parts at random; we have weighed them, computed an average and calculated the standard deviation from the deviations from the average in according with the following formula:

$$\sigma = \sqrt{\frac{\Sigma(x_i - \bar{x})^2}{n-1}}$$

$\sigma$ designates the standard deviation, $x_i$ the weight of the individual filers, $\bar{x}$ the average weight and n the number of filters that have been weighed.

To know the deviations of filter weights from one another is important because the fiberglass material, along with other substances, contains lead which was to be determined. Going on the assumption that the fiberglass material contains equal amounts of lead per unit of weight, then different amounts of impurities are introduced into the samples to be tested if, as is common practice, we were proceeding on the assumption of definite filter areas of equal size. For analysis, half of one filter is processed and not 1 g of filter material, which would be considerably more troublesome to extract from a filter weighing approximately 3.3 g (20 x 25 cm).

The results of the weighing of the air-dried filters are shown in Appendix 1.

The weights in one shipment do not vary greatly in general; their standard deviations are still below 1%; the maximum difference from shipment to shipment was around 10%. In practice, these figures mean the following:

The acid extract of half a fiberglass filter introduces into the analytical process about 15 µg of lead from the filter, which must be taken into account. However, on an equal area during a one hour-long period of sampling and a throughput of air of around 80 $m^3/h$ at a lead content of .5 $\mu g/m^3$ (low concentration) in the atmosphere 20 µg, and at a concentration of 10 $\mu g/m^3$ (high concentration) 400 µg of lead are deposited. At lead concentration on the order of magnitude of .5 $\mu g/m^3$ we are already approaching the range naturally set by the lead content of the precipitation medium. If filter weights (and in consequence the introduced amount of lead) also vary greatly, then the detectable limit is still higher. It is advisable to keep in store for a certain project of investigation as many filters of ONE MANUFACTURE as are necessary to ensure the carrying-out of the entire program.

### 3.312 WEIGHT CONSTANCY OF FIBERGLASS FILTERS

For the purpose of establishing the conditions under which fiberglass filters assume a constant weight within 1/10 mg we conducted drying tests at various temperatures. The findings, representing a mean of five measurements, are shown in Table 1.

Constant weight is already achieved with drying over night; at 50°C the filters still do not release any considerable amount of moisture. A

significant loss does not ensue before 105°C; after 2 hours the filters lost .13% and after another 14 hours .15%, a total of .28%. During such a vigorous drying the surface of the fibers are deprived of their natural moisture and the fibers become hydrophilic and increase in weight during weighing on the scale. This does not happen if the filters are dried at room temperature. Something else argues for drying of the samples in air: the natural condition of the deposited aerosol remains intact to the greatest degree; in any case, no such intensive changes occur as with vigorous drying at 105°C over a prolonged period of time (e.g. by desorption of unpolar substances). In consequence, dust concentration measurements made simultaneously with lead determinations were performed after drying at room temperature. The data, therefore refer to air-dried dust.

TABLE 1

WEIGHT LOSS UNDER DIFFERENT CONDITIONS

| Filterbezeichnung b | a Gewichtsabnahme und Schwankungsbreite in Prozent. 14 h/ Zimmertemperatur c | 2 h/ 50 °C | 2 h/ 75 °C | 2 h/ 105 °C | 14 h/ 105 °C | 24 h/ 105 °C |
|---|---|---|---|---|---|---|
| SS Nr. 9 | 0 | 0 | 0,07 | 0,13 | 0,15 | 0,007 |
| G. L 60 | 0,002 | 0,002 | 0,02 | 0,02 | 0,02 | 0,002 |

Key: a) Weight loss and range of variation in percent

b) Filter designation

c) 14h/room temperature

3.313 HYDROPHILIA

In order to test whether filters that had possibly become wet would retain water to any significant degree, air-dried, weighed filters were

heavily sprayed with water and weighed after a repeated similar drying. Subsequent to this treatment the average weight increase for both types of filters (SS.No.9 and G.L 60) amounted to .08% ± .02%. The results of this test point to strong hydrophobia of the fiberglass filters. Moisture, possibly condensed by capillary action during sampling, is eliminated already at room temperature to a negligibly small amount.

3.314 PERMEABILITY TO AIR

The permeability of the two types of glass fibers SS. No.9 and G.L 60 as well as their behavior over a period of 5 hours has already been depicted in Fig.4. Under the noted conditions it amounts for both filters to about 98 $m^3/h$ (depending though on the individual device). Only rarely were we able to establish a change in throughput of air during atmospheric sampling in 24 hour measurements. Drops, amounting at the outside to 10%, can in such a case be explained by interference due to dust deposits. Occasionally, permeability to air greater than at the beginning could be recorded. These findings cannot be explained by a change in the property of permeability to air of the filter itself, which can only become less permeable to air by becoming clogged and by swelling; it might be possible to explain it by an increased output of the suction motor brought on by a change in temperature and voltage. We have never encountered a drop of permeability to air from 60 cfm to 20 cfm as decribed in US literature. However, we did determine in an experiment that spraying the filter with finely dispersed water (vaporizer) caused the throughput to quickly drop to zero due to clogging of the pores. This leads to the conclusion that a severe drop can also be brought about through a dense fog. Our one-hour samples were taken on fog-free days on rain-protected devices and no change

in permeability was observed.

3.315 CHEMICAL COMPOSITION

During the desorption of lead with acid for analytical determination it must must be expected that a certain portion of the fiberglass material goes in solution. For this reason acid extracts of fiberglass filters were prepared under the same condition that were in effect later on during the desorption of the lead samples, and they were then subjected to a chemical analysis. For the preparation of the acid extract 1 g of fiberglass material was separated by boiling for ten minutes with 50 ml of a mixture of $HNO_3$ + HCl + $H_2O$ in the ratio of 1:1:1, filtered by suction and rewashed five times with 20 ml of .2 n-$HNO_3$. The substance dissolved in acid was concentrated by evaporated and weighed as acid soluble, the residue was fired at 600°C after having been dried at 105°C and weighed as residue. The portions soluble in acid as well as the ones insoluble in it were analyzed chemically and the insoluble residue was first disolved by means of suitable solubilization (Table 2).

TABLE 2

ACID SOLUBLE MATERIAL AND RESIDUE FROM FIRING OF MATERIAL INSOLUBLE IN ACID FROM 1 g OF AIR-DRIED FIBERGLASS MATERIAL.

| | a Säurelösliches mg | b Glührückstand des Unlöslichen |
|---|---|---|
| Schleicher u. Schüll Nr. 9 | 62,9 | 864,2 |
| Gessner L 60 | 52,9 | 862,8 |

Key: a) Acid-soluble parts

b) Residue from firing of insoluble parts

The acid soluble components were analyzed as follows:

| | |
|---|---|
| Dissolved silicic acid - $SiO_2$: | boiled down with HCl, weighed, weighed out again as weight differential subsequent to evaporating with HF. |
| Iron, $Fe_2O_3$: | photometrically with thioglycolic acid |
| Aluminum, $Al_2O_3$: | gravimetrically as oxide |
| Barium, Ba: | gravimetrically as sulfate |
| Calcium, Ca: | by titration with oxalic acid |
| Magnesium, Mg: | with complexon |
| Potassium, K: | flame photometrically |
| Sodium, Na: | flame photometrically |
| Lead, Pb: | with dithizone |
| Zinc, Zn: | with dithizone |
| Copper, Cu: | with zincdibenzyldithiocarbamate |
| Thallium, Tl: | with dithizone |
| Bismuth, Bi: | with dithizone |

In the residue from firing of the acid-insoluble components the noted substances were determined by means of the same method; in addition, boron as calcium borate subsequent to distilling over with methyl alcohol was collected in a $Ca^{2+}$ solution.

The results of a chemical analysis are shown in Tables 3 and 4 below.

For the results of lead determination it is important to ascertain the relative quantities of impurities introduced into the analysis. 1 g of fiberglass filter corresponds to approximately one third of a filter in area on which between 6 and 260 µg of lead accumulate during a one hour

period of sampling (see page 15). Taking into account the blank value and the range of variation of an analytical determination, then the amount of lead alone being introduced into the analysis from the fiberglass material is sufficient to render impossible an exact analytical determination at the very low lead concentrations of the atmosphere (below .5 $\mu/m^3$) due to droping below the detectable limit. The acid-insoluble components still contain about 30 µg of lead per gram of fiberglass material, i.e. about three times the amount of soluble material; if a solubilization of the entire filter were performed, four times as much lead as acid solubilizer would be introduced into the analysis and in consequence the blank value and the detectable limit would be considerably increased. Thallium and bismut, which are not distinguished from lead under the conditions of analysis specified later, are not contained in the fiberglass material. These two metals are not to be expected in the atmospheric dust. Iron and aluminum as well as the alkaline earth metals as well as zinc, which are introduced into analysis in quantities on the order of magnitude of grams (i.e. hundred to thousand times the amount of lead) must be restrained by means of suitable camouflage agents. The alkaline metals do not interfere with analysis, they are even added in not inconsiderable quantities.

## 4. LEAD DETERMINATION

When considering the method for the determination of small amounts of lead in the atmosphere the first consideration must be to make the operating procedure at a degree of absolute reliability so simple that it can be performed in any physico-chemical laboratory. The photometric determination with dithizone, and in this case the monochromatic process, has proved

to be such a method. Other methods of determining atmospheric lead, such as the spectrographic one, the turbidimetric and the polarographic one require more effort and other sampling conditions.

TABLE 3

INGREDIENTS OF ACID-SOLUBLE MATERIAL FROM 1 g OF FIBERGLASS FILTER

| | | | a Stoffmenge in mg | |
|---|---|---|---|---|
| | | | Schleicher und Schüll Nr. 9 | Gessner L 60 |
| b | gelöste Kieselsäure | $SiO_2$ | 3,9 | 5,5 |
| c | Eisen | $Fe_2O_3$ | 1,2 | 1,2 |
| d | Aluminium | $Al_2O_3$ | 7,3 | 9,2 |
| e | Barium | Ba | 1,6 | 3,4 |
| | Kalzium | Ca | 12,5 | 13,2 |
| | Magnesium | Mg | 3,9 | 2,8 |
| f | Kalium | K | 6,6 | 8,2 |
| g | Natrium | Na | 5,3 | 7,1 |
| h | Blei | Pb | 0,010 | 0,012 |
| j | Zink | Zn | 1,2 | 1,0 |
| k | Kupfer | Cu | 0,020 | 0,010 |
| l | Thallium | Tl | — | — |
| | Wismut | Bi | — | — |

Key: a) Quantity of material in mg
b) Dissolved silicic acid
c) Iron
d) Aluminum
e) Calcium
f) Potassium
g) Sodium
h) Lead
j) Zinc
k) Copper
l) Bismut

TABLE 4

INGREDIENTS IN RESIDUE OF FIRING THE ACID-INSOLUBLE MATERIAL FROM 1 g OF FIBERGLASS FILTER

| | | | a Stoffmenge in mg | |
|---|---|---|---|---|
| | | | Schleicher und Schüll Nr. 9 | Gessner L 60 |
| b | Kieselsäure | $SiO_2$ | 546,0 | 588,0 |
| c | Borsäure | $BO_3$ | 93,0 | 88,7 |
| d | Eisen | $Fe_2O_3$ | 3,6 | 4,3 |
| e | Aluminium | $Al_2O_3$ | 31,5 | 38,0 |
| | Barium | BaO | 40,9 | 47,0 |
| f | Kalzium | CaO | 12,2 | 10,4 |
| | Magnesium | MgO | 6,3 | 6,6 |
| g | Kalium | K | 14,7 | 11,0 |
| h | Natrium | Na | 45,7 | 53,0 |
| j | Blei | Pb | 0,029 | 0,032 |
| k | Zink | Zn | 22,0 | 19,7 |
| l | Kupfer | Cu | 0,025 | 0,018 |
| | Thallium | Tl | — | — |
| m | Wismut | Bi | — | — |

Key: a) Quantity of material in mg
b) Silicic acid
c) Boric acid
d) Iron
e) Aluminum
f) Calcium
g) Potassium
h) Sodium
j) Lead
k) Zinc
l) Copper
m) Bismut

4.1 SPECTROPHOTOMETRIC ANALYSIS OF LEAD DITHIZONATE

The determination of lead in accordance with the dithizone method is based on the fact that lead forms a strongly red colored compound with

dithizone, (diphenylthiocarbazone, $C_6H_5.N : N.CS.NN.NN.C_6H_5$): lead dithizonate ($Pb(HDz)_2$, soluble in organic solvents, that can be determined photometrically. The color intensity of $Pb(HDz)_2$ solution corresponds to a certain concentration; the LAMBERT-BEER law, i.e. linearity of extinction against concentration, is met in the range of 0 to 80 µg of Pb per 25 ml. Dithizone ($H_2Dz$) forms dithizonate also with other metals. By means of selecting suitable operating conditions, such as the addition of complexing agents (prevention of the precipitation of tri- and multivalent metals), reducing agents and buffers, but above all by extraction in a narrower pH range, it is possible to make the reaction for lead largely specific. Bismut and thallium, as already noted, cannot be differentiated from lead according to this process.

These are the individual operating procedures:

1. SAMPLING, i.e. concentration of a certain amount of lead-containing dust.
2. PREPARATION OF THE SAMPLE FOR ANALYSIS: loosening of the lead dust from the filter and separating it from insoluble matter.
3. ANALYSIS: extraction of the lead as $Pb(HDz)_2$ with a slight surplus of $H_2Dz$; eduloration of the dithizone surplus and photometric determination.

The exact performing of the analysis requires a certain amount of breaking in, and furthermore, special attention must be paid to cleanliness of the work area. The glass vessels used for analysis, such as separatory funnel, filtering flask and others must be cleaned with nitric acid and chloroform prior to use and rinsed with water; only twice distilled water must be used for this purpose.

It is recommended that utensils once used for lead determination be reserved for that purpose; for analyses in series the same separatory funnels should always be used again.

Before going into detail regarding exact working instructions (sampling and analysis) we will report on some experiments that were conducted before or during the course of studies for determining the most suitable conditions, but also in part for the purpose of simplifying the analysis.

The absorption bands of $Pb(HDz)_2/CHCL_3$ solution are shown in Fig.6 (Spectrophotometer Zeiss, 1 cm layer thickness).

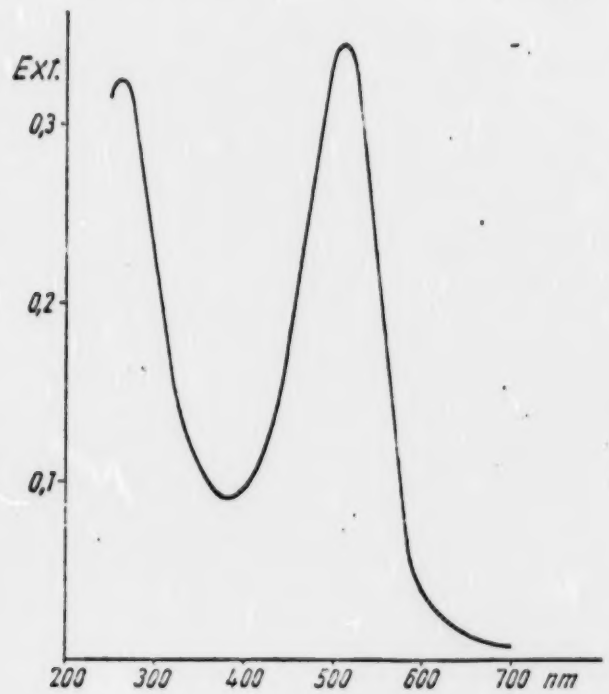



Fig.6. Spectrophotometric analysis of $Pb(HDz)_2/CHCL_3$
Spectrophotometer Zeiss

According to the spectrophotometric analysis a strong, rather narrow band with a maximum around 515 nm lies in the visible range. The use of filter S 51 is recommended for the Elko II photometer; it best transmits the carmine red light of this range. Besides this filter the filter S 53, which passes light of a somewhat longer wave length, has been employed simultaneously in a great number of series. The comparison measurements with S 51 and S 53 were based on the conjecture that the extinctions measured with S 53 would scatter less than the ones with S 51. However, this assumption proved incorrect: since extinctions with S 53 were lower than with S 51, but scattering proved to be equally great, there was no reason to prefer the S 53 filter to the S 51 filter.

4.2 pH RANGE OF LEAD EXTRACTION

In order to determine the most favorable pH range in which lead dithizonate forms (and dissociates simultaneously) we have shaken equal quantities of $Pb(HDz)_2$, manufactured to our specifications, with buffer solutions of different pH values from 7 to 12.5; subsequent to the establishing of equilibrium the layers were separated and the lead dithizonate was photometrically determined in the Elko II with the use of four different filters. The diagram (Fig.7) shows that lead dithizonate in chloroform is most stable between pH 10 and 11 and that the stability is still satisfactory in the range of the adjacent pH units. If you would want to extract with a single shaking out it would be necessary to operate in the maximum. However, with the process recommended here, using triple shaking out, the range between pH 9 and 10 is also favorable, especially since in this not too alkaline range considerably less dithizone is picked up from

the aqueous phase. In accordance with these findings we recommend an extraction between 9.2 and 9.5.

At a pH value above 11, $Pb(HDz)_2$ begins to dissociate; for this reason the edulcorating of the surplus $H_2Dz$ used for extraction must not take place at a too high pH value.

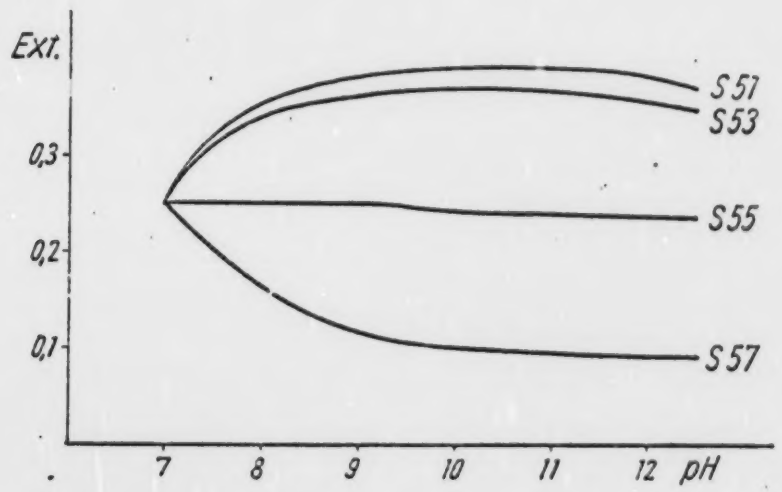



Fig.7. Stability of lead dithizonate at various pH values

4.3 SINGLE OR DOUBLE EXTRACTION

In case of larger amounts of impurity ions, especially higher value cations, being present which are introduced into the analysis by the fiberglass material as well as by the atmospheric dust, the recommendation in the literature is frequently to the effect that the $Pb(HDz)_2$ won after the first extraction should be decomposed with nitric acid and extracted once more. This measure is practically equal to a purification of the lead dithizonate, as it causes the separation of possibly present multivalent cations extracted along with the dithizone. We also performed our first de-

terminations in this manner (two extractions). However, it seemed reasonable to limit the analysis to ONE extraction, as it is also described in the unit process of the water analysis. It is true that suitable experiments with double extraction resulted in a somewhat lower middle extinction than with a single one, but the standard deviation - and that is the criterion for evaluating the quality of the analysis - remained in the same order of magnitude. An example of this kind is given in Appendix 2. Even though the higher extinction of the first extraction might be traced back to slight traces of impurities, that would be immaterial in this case because the calibration curve is produced in the same manner and with the same impurities.

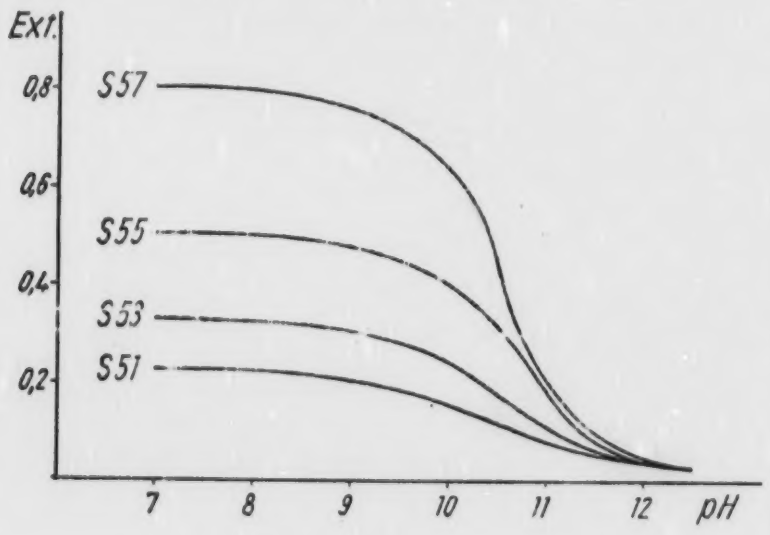



Fig.8. Extinction remaining after a single extraction of a $H_2Dz/CHCl_3$ solution with wash solutions of various pH values. Initial solution: 10 ml 75 µmole $H_2Dz$. The wash solution was adjusted according to specification with ammonium citrate or ammonia.

## 4.4 pH RANGE OF EDULCORATING SURPLUS DITHIZONE

In order to investigate this problem we agitated pure dithizone/chloroform solutions once with wash solutions of different pH values and analized photometrically the coloration still remaining in the organic phase, utilizing various filters. As expected, dithizone passed over into the aqueous phase more readily the higher the pH value.

On the other hand, the decomposability of $Pb(HDz)_2$ in a strongly alkaline range sets a limit (also see Fig.8); our wash solution had a pH value of 11.2. However, it is necessary to shake out repeatedly in order to extract all surplus dithizone from the solution.

## 4.5 CLOSER pH VALUE OF EDULCORATION

On the basis of the two preceding experiments the fact was established semiquantitatively that the edulcoration range of the surplus dithizone should move between pH 10 and about 12. For the purpose of narrowing down this range we have again performed a series of experiments in which a given dithizone/chloroform solution was repeatedly shaken out with wash solutions of different pH values. The results of these experiments are shown in Fig.9.

The following can be gathered from the diagram: with a wash solution having a pH value between 11 and 11.5 only a slight extinction remains after triple shaking out which cannot be reduced to any significant extent by further shaking out. As lowest and therefore most favorable pH value at which shaking out can be performed we consider a value of 11.2, to which our wash solutions are being adjusted.

4.6 FREQUENCY OF EDULCORATIONS

Experiments to perform edulcorations more than three times (up to seven times) showed that a minimum of remaining dithizone extinction had been practically reached with a wash solution of pH value 11.2. It is not necessary to edulcorate more than three times.

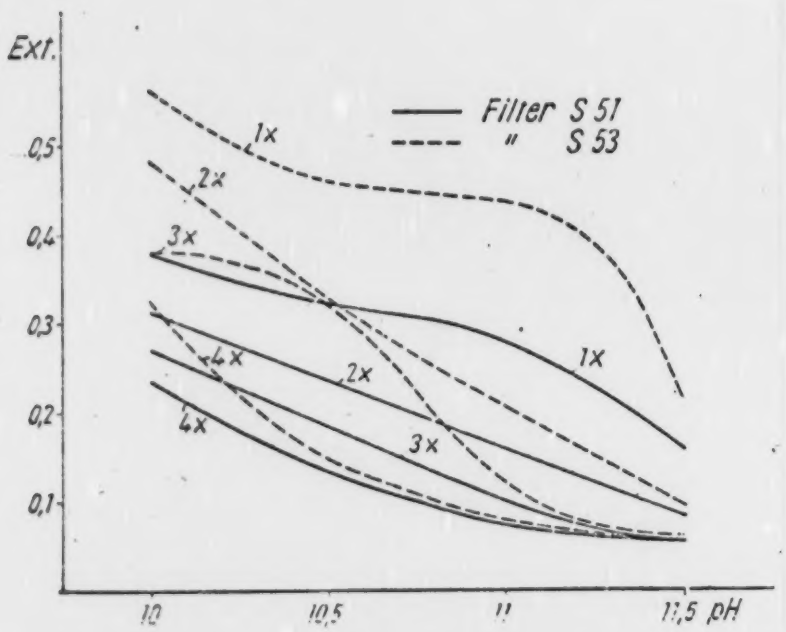



Fig.9. Remaining dithizone extinction after repeated shaking out with wash solutions of different pH values

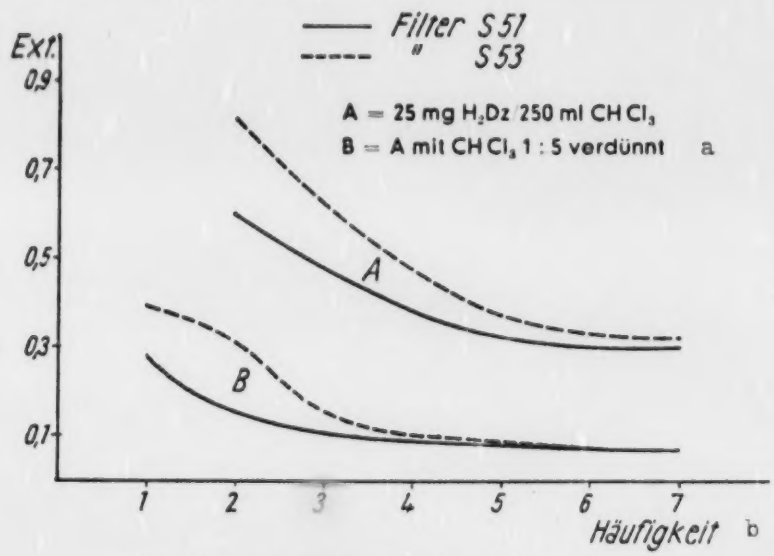
4.7 VARIATIONS OF SCREENING AND WASHING SOLUTIONS

In order to find out to what extent other screening and washing solutions were effective their chemical composition was varied with the result that these solutions of the wash solution of pH value 11.2 were at most equal to but never superior to it. We must, however, concede the fact that the sreening solution II (page 33) is not very stable and must be

renewed on decomposition which can easily be recognized visually by the fact that it is colored light to deep yellow.

## 4.8 PURIFICATION OF DITHIZONE

Frequent directions in literature, according to which dithizone must be subjected to a purification prior to use, probably stem from a time when dithizone was not on the market in today's grade of purity. Analytical determinations of known quantities of lead with non-purified dithizone by the firm of Merck did not result in any greater scattering of values than those with purified dithizone; the very cumbersome purifying of dithizone is therefore superfluous.




Key:

a) Diluted

b) Frequency

Fig.10. 10 ml $H_2Dz/CHCl_3$ SOLUTION WITH 10 ml KCN WASH SOLUTION OF pH 11.2 REPEATEDLY SHAKEN OUT.

## 5. OPERATING INSTRUCTIONS FOR ANALYTICAL LEAD DETERMINATION

The following operating instructions are given on the basis of the experiences and experiments that have been described:

## 5.1 SAMPLING

The air-dried filter (or if desired, dried at 105°C), which has been suitably provided with a number, is inserted in the 20 x 25 cm holder of the High Volume Sampler in such a way that it is not canted relative to the support. After starting the suction motor the throughput is read at the rotameter and the starting time is noted. During sampling, which always amounted to one hour, the reading is repeated, especially for a longer duration, but without fail at the end of sampling. Subsequent to taking the sample and in order to prevent any loss of the dust during transportation the filter is folded with the dust-containing side towards the inside and the sample is stored in a dust-tight plastic container. The edges of the dust layer should be sharp as there is otherwise danger of the dust not being evenly divided during distribution. A sharp edge of the dust sample is obtained by affixing a 1 cm wide strip of adhesive tape to the border of the filter support. According to experiments to date the fiberglass filters No.9 of the firm of Schleicher and Schüll and the filter L 60 of the firm of Gessner and Co. are suitable. Dust concentration is calculated from the gain in weight of the filter (drying as before sampling) as well as from the mean throughput of air.

## 5.2 PREPARATION OF SAMPLE FOR ANALYSIS

REAGENTS

NITRIC ACID 1 : 1 (SEMICONCENTRATED); concentrated nitric acid of 65% is diluted with the same volume of water.

NITRIC ACID .2 n; 15 ml of concentrated nitric acid of 65% filled with water to 1,000 ml.

AMMONIUM CITRATE SOLUTION : 50 g of ammonium citrate are dissolved in 250 ml of water. 10 ml of this solution contain 2 g of $NH_4$ citrate.

The filter is divided symmetrically; one half is stored for documentation or, if required, for control determination or for the determination of components subsequently recognized as important, the other half is prepared for lead (and possibly other) determination. The fiberglass half intended for preparation is inserted in a 400 ml beaker, 50 ml of semi-concentrated nitric acid is poured over it and boiled for 10 minutes under frequent stirring. The fiberglass material forms a semifluid paste that can still be stirred well with a glass rod. The lead as well as part of the dust go into solution; the beaker contents are strongly filtered off by suction in a hot condition through a G 2 frit that has previously been repeatedly boiled out with nitric acid and rewashed five times with hot 20 ml of .2 n nitric acid and some hot water. Subsequent to cooling off, the filtrate is poured into a 250 ml measuring flask, 10 ml of ammonium citrate solution are added (= 2 g) and filled up to the mark.

## 5.3 LEAD ANALYSIS

REAGENTS

25% concentrated ammonium

SCREENING SOLUTION I:

100 g of KCl and

25 g of hydroxylamine hydrochloride

with 200 ml of water and 10 ml of concentrated HCl added, dissolved under weak heating and filled to 500 ml after cooling. The strongly acid solution is stable for a prolonged period of time.

SCREENING SOLUTION II:

5 g of KCl

14 g of $K_2CO_3$

5.5 g of $(NH_4)_2CO_3$ and

2.5 g of ammonium citrate

dissolved in 100 ml of water. The solution must be stored in the dark and keeps only for a few days. Decomposition can be recognized by yellow coloration.

CHLOROFORM for dithizone determination

CHLOROFORM p.a.

Commercial chloroform p.a is frequently acid.

For the purpose of purification, 500 ml of $CHCl_3$ are mixed with 30 ml of concentrated ammonium and strongly agitated. The isolated chloroform phase is washed twice with water in order to remove the surplus ammonium.

DITHIZONE/CHLOROFORM SOLUTION

25 mg of dithizone p.a. Merck are dissolved in 250 ml of chloroform; for this purpose "Chloroform for the determination with dithizone" is used.

LEAD STANDARD SOLUTION

1.599 g of lead nitrate p.a. (corresponds to 1 g of lead) are dissolved in a 1 l measuring flask, adding 1 ml of concentrated $HNO_3$ in water and filled to the mark.

LEAD CALIBRATION SOLUTION

20 ml of standard solution are filled to 1,000 ml (dilution 1 : 50) and the diluted solution is again diluted 1 : 10. The two calibration

solutions contain 20 respectively 2 µg of lead in one ml.

INSTRUMENTS:

electric pH meter

Elko II, 1 cm cuvette, filter S 51.

50 ml of the prepared sample that must contain between 7 and 80 µg of lead are introduced into a 200 ml beaker, mixed with 5 ml of screening solution I and brought to a pH between 8 and 9 by means of a few drops of ammonium; then 5 ml of screening solution II (pH 10) are added and the pH value is adjusted to pH 9.2 to 9.5 with ammonium (conc.) (electric pH meter). This mixture is filled to 100 ml with water after being transferred to a 200 ml separatory funnel, then mixed with 2 ml of ditizone solution and vigorously shaken for 20 seconds. The specified duration of shaking out must be accurately adhered to. In the presence of relatively much lead the emerald-green dithizone solution is colored an intense red. However, if a slight $H_2Dz$ surplus is already present a mixed color resulting from both colors is produced. After separating the phases the lead dithizonate is drained off into a second separatory funnel and the aqueous phase is rinsed out with chloroform. The shaking out is repeated until the emerald-green color remains. However, attention must be paid to the fact that the dithizone surplus is a small as possible. As a rule the shaking out will be terminated after the third time.

The collected individual extractions that should not amount to more than 20 ml are mixed with 10 ml of wash solution for washing out of the surplus dithizone; after 20 s of shaking and dividing of the phases, separating is renewed. The aqueous, alkaline phase absorbs the surplus $H_2Dz$

and in the process is colored light yellow. The washing process is nearly always complete after three washings; the last wash water must be practically colorless. The washed carmine-red lead dithizonate is transferred to a 25 ml measuring flask by way of a folded filter to which some dried sodium sulfate is applied and after filling with chloroform up to the mark it is photometrically processed in the Elko II, using a 1 cm cuvette and filter S 51. On account of the volatility of chloroform it is recommended that the cuvettes be covered with a lid. The blank value of the cuvettes may not show any indication when they are exchanged. The blank value of the reagents and the blank value of the fiberglass filter must be deducted from the extinction value thus obtained; after deduction the quantity of lead contained in 50 ml from 250 ml is obtained by multiplying by the calibration factor (multiplication factor = 80.6). After further multiplication by 5 and by 2 the total quantity of lead is obtained that has been precipitated on the whole filter; this is used to calculate the lead concentration in $\mu g/m^3$ by means of dividing by the volume of air in $m^3$.

In case the lead content in the partial volume of 50 ml used for extraction is too small, i.e. below 7 µg, the determination must be repeated with 100 ml. As a rule, this will not be necessary because a quantity of 7 µg of lead, under the given operating conditions (80 $m^3$ of air in one hour), corresponds to a relatively low atmospheric lead concentration of .8 $\mu g/m^3$. For a longer sampling period it is necessary to start with a smaller partial volume for analysis. In all cases special attention must be paid to the fact that the blank value of the fiberglass filter depends on the partial volume introduced into analysis.

## 5.4 CALIBRATION CURVE

For the purpose of determining the factor of direction we first plotted a curve with pure lead solutions (theoretical factor of direction) in accordance with the above instructions and then another one with fiberglass filters added. Whereas the determination of the pure lead solution was undertaken directly after analysis, the one with fiberglass filters was dealt with in the same manner as sample preparations, i.e. the given quantity of lead was first boiled with half a fiberglass filter for 10 minutes etc in accordance with instructions. The values of 79.4 and 80.6 for the calibration factor agree well with and without fiberglass filter; the obligatory calibration factor, which applies to the entire analysis, is 80.6. The individual values of the calibration curves without fiberglass filter are shown in Appendix 3, the ones with fiberglass filter in Appendix 4.

## 5.5 REAGENT BLANK VALUE

Lead is present in practically all chemical compounds, thus also in the reagents used in these experiments, but also in the containers. In the course of successively determined reagent blank values the extinction dropped from an initial of about .038 (first determination) by way of .030, .024 to about .016. The lowest reagent blank value ever obtained was at .012. Doubling the total quantity of the reagent does not result in a higher extinction value. This leads to the assumption that the blank value of the reagents stems predominantly from the glass of the container. In addition it was found that the reagent blank values increase greatly if no determinations have been performed with the equipment for a few days. During this time the lead of the glass had occasion to diffuse to the surface.

The extinction of the third successively performed blank determina- with the same containers is commonly at a value of .020 ± 10%, which is a very good value to work with. Therefore, an easy requirement is that before undertaking determinations the blank value should drop to this value. In Appendix 3 - sheet 1 - there are some measured blank values the mean of which amounts to .019 (extinction).

5.6 BLANK VALUE FROM THE FIBERGLASS MATERIAL

Determination of the blank value resulting from the introduction of lead by the fiberglass was performed in two ways; one was by boiling half a filter with acid in accordance with instructions and analyzing an aliquot portion for lead; the other one was by analyzing the whole extract of 1 g of fiberglass filter obtained in the same manner. The individual findings of the aliquot portions are contained in Appendix 4, those of the 1 g of fiberglass filter in Appendix 6. The values obtained in this manner agree even theoretically for filters No.9 (Schleicher and Schüll) with 10.5 and 10.5 ug of Pb per filter. Consequently, half a filter contains 17.6 ug of acid-soluble lead. This amount of lead is therefore introduced into the analysis during the preparation of half a filter. However, only 50 ml out of 250 ml, or other aliquot portions are used for the determination, a fact already referred to above.

The total blank value (extinction) derives, therefore, from:

| | |
|---|---|
| from the reagents and containers | .019 |
| from the fiberglass at 50 ml out of 250 ml | .041 |
| Total | .060 |

When using for analysis 100 out of 250 ml the blank value of the fiberglass is doubled, for 25 out of 250 ml it is only one half (see Appendix 5).

Fiberglass filters L 60 by the firm of Gessner according to our determinations contained 12.2 µg of lead per g of material and thus a little more lead than filter No.9; however, they are just as suitable for sampling as the others (compare Appendix 6).

## 5.7 LIMIT OF DETECTABILITY

The limit of detectability was computed from the blank value of the entire analysis (see sections 5.5 and 5.6) and their standard deviation, with the limit set at $\bar{x} + 3\sigma$. The results of these experiments are shown in detail in Appendix 5; Table 5 contains the essential values.

TABLE 5

LIMIT OF DETECTABILITY ON WITHDRAWAL OF
AQUOT PORTIONS FROM 250 ml CONTENT.
1/2 FIBERGLASS FILTER SCHLEICHER AND SCHÜLL No.9

| Entnommen | 25 ml = 1/10 | 50 ml = 1/5 | 100 ml = 2/5 |
|---|---|---|---|
| Mittlere Extinktion $\bar{x}$ | 0,042 | 0,060 | 0,088 |
| Standardabweichung von $\bar{x}$ | 0,0058 | 0,0076 | 0,0104 |
| Nachweisbarkeitsgrenze Extinktion | 0,060 | 0,083 | 0,138 |
| µg Blei | 4,8 | 6,7 | 11,1 |
| µg Blei in 250 ml | 48,0 | 33,5 | 27,7 |
| µg Pb/m³ bei 80 m³/h und Probenahme 1 h | 1,2 | 0,8 | 0,7 |

Key: a) Withdrawn
b) Average extinction $\bar{x}$
c) Standard deviation from $\bar{x}$
d) Limit of detectability extinction
e) µg lead
f) µg lead in 250 ml
g) µg Pb/m³ at 80 m³/h and sampling 1 h

On withdrawal of 50 ml from 250 ml about 7 µg Pb must be present in the analysis, even 11.1 for 100 ml. The limit of detectability, expressed in µg $Pb/m^3$ of air, does not change as a consequence, due to the fact that for the analysis of a larger portion correspondingly larger amounts of lead are also introduced from the fiberglass.

5.8 REPRODUCIBILITY

Quantities of lead from 10 to 80 µg are readily analyzed in accordance with the noted method. The relative standard deviations for 10 µg amounted to 5.7%, for 20 µg to 3.3%, for 40 µg to 1.6% and for 60 µg to 1.5% (also see Appendix 4). The determinations were performed in such a manner that five times the amount of lead required for analysis was added to half a fiberglass filter, the sample was brought to a boil and analyzed further in accordance with instructions. 50 ml out of 250 of this solution corresponded to the desired amount of lead. The following was found on an average for ten measurements:

| a Vorgegeben: | b Gefunden: | c rel. Abweichung |
|---|---|---|
| 10 µg | 9,7 µg | 3,0 % |
| 20 µg | 19,8 µg | 1,0 % |
| 40 µg | 40,1 µg | 0,25 % |
| 60 µg | 60,3 µg | 0,5 % |

Key: a) Given b) Found c) Rel. deviation

6. LEAD CONTENT OF AIR IN STREETS

For the purpose of determining the lead content in the atmosphere a total of 245 samples have been taken in the cities of Mülheim (Ruhr), Düsseldorf, Neuß on the Rhein, Duisburg and the Wuppertal and analyzed in ac-

cordance with the dithizone method. The values are shown in detail in Appendix 7 and 11. The values of dust concentrations determined simultaneously with these measurements are contained in Appendix 12 to 16, while the percentage of lead in the dust are in Appendix 17 to 21.

The samples were taken at a distance of about 50 cm from the road on the sidewalk, 1 m above the ground. The sampling device was set up in such a manner that its filter was positioned on the side away from the road. The number of passing vehicles was counted in each case; the measuring locations were in heavily traveled streets or places. In addition, a measuring point was also established in each city at a location that had no or only very little traffic. These measuring points - to be regarded as zero positions - are in each case last in the Appendix.

The lead concentrations that we determined varied from .5 $\mu g/m^3$ to 12.5 $\mu g/m^3$. Most values were between 1 and 4 $\mu g/m^3$ (60%, with a distribution of 20% respectively for a range of concentrations 1 to 2, 2 to 3 and 3 to 4 $\mu g/m^3$); about 20% of the values were above 5 $\mu g/m^3$. The frequency distribution can be seen in detail in Appendix 22. The median value (interpolated straight line of the S curve, Appendix 23) amounts to 3.2 and the 95% value to 8.3 µg of lead/$m^3$. The impact of the lead does not seem to depend on the vehicle density. Weather conditions as well as local conditions due to city planning (narrow streets, open squares) obviously exert a strong influence on the lead content in the air.

The "zero" positions exhibit a not inconsiderable lead content. This indicates that lead dust can be transported by air over long stretches of ground. The dust content in streets at an elevation of 1 m is extraordinarily high with an amount up to 1.72 $mg/m^3$. The lead content of dust is generally beow 1%.

## 7. FINAL OBSERVATIONS

To the best of our knowledge the studies of this research project represent the first investigation of lead in the atmosphere in the Federal Republic of Germany that have been undertaken on a large scale. With a measuring time interval of one hour this method is sufficiently accurate to determine the lead content on a reproducible scale. For lead contents below the limit of detectability the sampling time would have to be extended. This is quite feasible because in general variations in concentration are smaller at locations with lower impact.

Some still unsolved problems are to be investigated further within the framework of institutional tasks. In detail we are dealing with the following studies:

1. To investigate which part of the atmospheric dust is respirable.
2. To investigate variations in concentration depending on the time of day from 0 to 24 hours at different locations, taking into consideration vehicle density and weather conditions.
3. To determine the lead content in the atmosphere at different elevations (among others also in skyscrapers).
4. To test the suitability of microsorban filters for deposition media.
5. To investigate the atmospheric lead content leeward of lead emitting plants.

Key to Appendix 1 page 43:

a) Weights of filters in g of fiberglass filters from different shipments

b) Acid extract foaming strongly, forms stable emulsions with chloroform, not suitable for Pb determination in accordance with dithizone method

c) Sum

d) Mean value

e) Difference from mean value

f) Standard deviation

Key to Appendix 2 page 44:

a) Standard deviation by dissolving and reprecipitating of $Pb(HDz)_2$ and renewed shaking out. Comparison with one-time shaking out. Submitted sample.....

b) One extraction (not reprecipitated)

c) Two extractions (reprecipitated)

Key to Appendix 3 page 45:

a) Calibration curve: Submitted quantity.....directly determined. Final volume.....

b) Submitted sample No.

c) .....Blank value.....

d) Calibration factor.....

e) Direction factor.....

Key to Appendix 3 (continued) page 46:

a) Appendix 3 (continued)

b) Submitted sample No.

Anlage 1

Filtergewichte in g von Glasfaserfiltern verschiedener Lieferung. a

| Schleicher und Schüll Nr. 9 | | | | Gessner L 60 | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | Δ mg | |
| 1) | 4,351 | Säureauszug stark | b | 1) | 3,125 | 2 | |
| 2) | 4,400 | schäumend, bildet | | 2) | 3,137 | 10 | |
| 3) | 4,112 | mit Chloroform | | 3) | 3,131 | 4 | |
| 4) | 4,352 | stabile Emulsionen, | | 4) | 3,118 | 9 | |
| 5) | 4,387 | für Pb-Bestimmung | | 5) | 3,121 | 6 | $\sigma$ = 26 |
| 6) | 4,111 | nach der Dithizon- | | 6) | 3,196 | 67 | $\sigma_{rel}$ = 0,85 % |
| 7) | 4,373 | methode ungeeignet | | 7) | 3,114 | 13 | |
| 8) | 4,394 | | | 8) | 3,109 | 16 | |
| 9) | 4,166 | | | 9) | 3,109 | 16 | |
| 10) | 4,293 | | | 10) | 3,114 | 13 | |
| Σ | 42,939 | | | Σ | 31,272 | | |
| x̄ | 4,294 | | | x̄ | 3,127 | | |
| | | Δ mg | | | | Δ mg | |
| 1) | 3,326 | 22 | | 1) | 3,241 | 9 | |
| 2) | 3,323 | 25 | | 2) | 3,221 | 11 | |
| 3) | 3,317 | 31 | | 3) | 3,225 | 7 | |
| 4) | 3,327 | 21 | | 4) | 3,216 | 16 | |
| 5) | 3,318 | 30 | $\sigma$ = 28 | 5) | 3,229 | 3 | $\sigma$ = 9 |
| 6) | 3,377 | 29 | $\sigma_{rel}$ = 0,8 % | 6) | 3,232 | — | $\sigma_{rel}$ = 0,35 % |
| 7) | 3,368 | 20 | | 7) | 3,236 | 4 | |
| 8) | 3,364 | 16 | | 8) | 3,241 | 9 | |
| 9) | 3,375 | 27 | | 9) | 3,239 | 7 | |
| 10) | 3,384 | 36 | | 10) | 3,240 | 8 | |
| Σ | 33,479 | | | Σ | 32,320 | | |
| x̄ | 3,348 | | | x̄ | 3,232 | | |
| | | Δ mg | | | | Δ mg | |
| 1) | 3,316 | 9 | | 1) | 2,876 | 22 | |
| 2) | 3,314 | 11 | | 2) | 2,899 | 1 | |
| 3) | 3,314 | 11 | | 3) | 2,909 | 9 | |
| 4) | 3,320 | 5 | | 4) | 2,979 | 78 | |
| 5) | 3,313 | 12 | $\sigma$ = 17,5 | 5) | 2,977 | 79 | $\sigma$ = 43,4 |
| 6) | 3,314 | 11 | $\sigma_{rel}$ = 0,5 % | 6) | 2,859 | 39 | $\sigma_{rel}$ = 1,7 % |
| 7) | 3,320 | 5 | | 7) | 2,867 | 31 | |
| 8) | 3,322 | 3 | | 8) | 2,867 | 31 | |
| 9) | 3,362 | 37 | | 9) | 2,869 | 29 | |
| 10) | 3,352 | 27 | | 10) | 2,885 | 13 | |
| Σ | 33,247 | | | Σ | 28,984 | | |
| x̄ | 3,325 | | | x̄ | 2,898 | | |

Σ = Summe c

x̄ = Mittelwert d

Δ mg = Differenz zum Mittelwert e

σ = Standardabweichung f

(See page 42 for key)

Anlage 2

Standardabweichung durch Umfallen des $Pb(HDz)_2$ und erneutes Ausschütteln, Vergleich zum einmaligen Ausschütteln.
Vorlage: 20 µg Pb — a

| | Eine Extraktion (nicht umgefällt) — b | | | Zwei Extraktionen (umgefällt) — c | | |
|---|---|---|---|---|---|---|
| | E $x_i$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | E $x_i$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ |
| 1) | 0,271 | — | — | 0,227 | 6 | 36 |
| 2) | 0,274 | 3 | 9 | 0,229 | 4 | 16 |
| 3) | 0,276 | 5 | 25 | 0,235 | 2 | 4 |
| 4) | 0,268 | 3 | 9 | 0,234 | 1 | 1 |
| 5) | 0,265 | 6 | 36 | 0,230 | 3 | 9 |
| 6) | 0,271 | — | — | 0,235 | 2 | 4 |
| 7) | 0,267 | 4 | 16 | 0,231 | 2 | 4 |
| 8) | 0,270 | 1 | 1 | 0,239 | 6 | 36 |
| 9) | 0,270 | 1 | 1 | 0,239 | 6 | 36 |
| 10) | 0,275 | 4 | 16 | 0,235 | 2 | 4 |
| $\Sigma$ | 2,707 | | 113 : 9 = 12,5 | 2,334 | | 150 : 9 = 16,6 |
| $\bar{x}$ | 0,271 | | | 0,233 | | |
| $\sigma$ | 0,0035 | | | 0,004 | | |
| $\sigma_{rel}$ | 1,3 % | | | 1,8 % | | |

(See page 42 for key)

Eichkurve: Vorgelegte Menge a µg Pb direkt bestimmt.
Endvolumen 25 ml, $E_{10\,mm}$, Photometer Elko II, Filter S 51.

a

Anlage 3

| vorgelegt | 0 µg Pb Blindwert (Bl) | | | 5 µg Pb | | | 10 µg Pb | | | 20 µg Pb | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Proben-Nr. | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ |
| 1) | 0,018 | 1 | 1 | 0,087 | 4 | 16 | 0,140 | 6 | 36 | 0,278 | 6 | 36 |
| 2) | 0,020 | 2 | 4 | 0,089 | 6 | 36 | 0,144 | 2 | 4 | 0,275 | 3 | 9 |
| 3) | 0,019 | — | — | 0,079 | 4 | 16 | 0,148 | 2 | 4 | 0,274 | 2 | 4 |
| 4) | 0,016 | 3 | 9 | 0,074 | 9 | 81 | 0,139 | 7 | 49 | 0,277 | 5 | 25 |
| 5) | 0,017 | 2 | 4 | 0,076 | 7 | 49 | 0,148 | 2 | 4 | 0,271 | 1 | 1 |
| 6) | 0,017 | 2 | 4 | 0,091 | 8 | 64 | 0,149 | 3 | 9 | 0,269 | 3 | 9 |
| 7) | 0,018 | 1 | 1 | 0,085 | 2 | 4 | 0,151 | 5 | 25 | 0,268 | 4 | 16 |
| 8) | 0,020 | 1 | 1 | 0,082 | 1 | 1 | 0,151 | 5 | 25 | 0,267 | 5 | 25 |
| 9) | 0,019 | — | — | 0,080 | 3 | 9 | 0,146 | — | — | 0,269 | 3 | 9 |
| 10) | 0,021 | 2 | 4 | 0,085 | 2 | 4 | 0,142 | 4 | 16 | 0,270 | 2 | 4 |
| 11) | 0,020 | 1 | 1 | 0,079 | 4 | 16 | | | | 0,275 | 3 | 9 |
| 12) | 0,021 | 2 | 4 | 0,083 | — | — | | | | 0,271 | 1 | 1 |
| 13) | 0,019 | — | — | | | | | | | | | |
| 14) | 0,020 | 1 | 1 | | | | | | | | | |
| $\Sigma$ | 0,261 | | 34 : 13 | 0,990 | | 296 : 11 | 1,458 | | 172 : 9 | 3,264 | | 148 : 11 |
| $\bar{x}$ | 0,019 | | = 2,6 | 0,083 | | = 26,9 | 0,146 | | = 19,1 | 0,272 | | = 13,4 |
| $\sigma$ | 0,0016 | | | 0,0052 | | | 0,0044 | | | 0,0037 | | |
| $\sigma_{rel}$ | 8,9 % | | | 6,2 % | | | 3,5 % | | | 1,4 % | | |
| $\bar{x}$—Bl | | | | 0,064 | | | 0,127 | | | 0,253 | | |
| d Eichfaktor: µg Pb/E | | | | 78,1 | | | 78,8 | | | 79,1 | | |
| e Richtungsfaktor: E/µg Pb | | | | 0,0128 | | | 0,0127 | | | 0,0127 | | |

b

c

(See page 42 for key)

Anlage 3 (Fortsetzung)

| vorgelegt | 40 µg Pb | | | 60 µg Pb | | | 70 µg Pb | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Proben-Nr. | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | |
| 1) | 0,535 | 5 | 25 | 0,774 | 4 | 16 | 0,926 | 20 | 400 | Mittlerer Eichfaktor aus 20, 40, 60 und 70 µg Pb |
| 2) | 0,529 | 1 | 1 | 0,785 | 15 | 225 | 0,901 | 5 | 25 | 79,1 |
| 3) | 0,529 | 1 | 1 | 0,765 | 5 | 25 | 0,898 | 2 | 4 | 78,3 |
| 4) | 0,518 | 12 | 144 | 0,765 | 5 | 25 | 0,893 | 3 | 9 | 79,9 |
| 5) | 0,527 | 3 | 9 | 0,750 | 20 | 400 | 0,922 | 24 | 576 | 79,8 |
| 6) | 0,525 | 5 | 25 | 0,778 | 8 | 64 | 0,893 | 3 | 9 | |
| 7) | 0,533 | 3 | 9 | 0,772 | 2 | 4 | 0,871 | 25 | 625 | 317,1 $\bar{E}_f = 79,4$ |
| 8) | 0,540 | 10 | 100 | 0,773 | 3 | 9 | 0,898 | 2 | 4 | |
| 9) | 0,533 | 3 | 9 | 0,763 | 7 | 49 | 0,899 | 3 | 9 | |
| 10) | 0,531 | 1 | 1 | 0,775 | 5 | 25 | 0,873 | 23 | 529 | |
| $\Sigma$ | 5,300 | | 324 : 9 | 7,701 | | 842 : 9 | 8,964 | | 2210 : 9 | Mittlerer Richtungsfaktor aus 20, 40, 60 und 70 µg Pb |
| $\bar{x}$ | 0,530 | | = 36,0 | 0,770 | | = 93,4 | 0,896 | | = 245,5 | 0,0127 |
| $\sigma$ | 0,006 | | | 0,0097 | | | 0,0157 | | | 0,0128 |
| $\sigma_{x,1}$ | 1,1 % | | | 1,2 % | | | 1,8 % | | | 0,0125 |
| $\bar{x}$—Bl | 0,511 | | | 0,751 | | | 0,877 | | | 0,0125 |
| Eichfaktor | 78,3 | | | 79,9 | | | 79,8 | | | 0,0505 $\bar{R}_f = 0,0126$ |
| Richtungsfaktor | 0,0128 | | | 0,0125 | | | 0,0125 | | | |

(See page 42 for key)

(continued on page 47)

Key to Appendix 3 (continued) page 46:

c) Mean calibration factor from.....

d) Mean direction factor from.....

e) Calibration factor

f) Direction factor

Key to Appendix 4 page 48:

a) Calibration curve: 1/2 fiberglass filter.....

b) Submitted - withdrawn from it

c) Calibration factor

d) Direction factor

e) Mean calibration factor from....

f) Mean direction factor from.....

Key to Appendix 5 page 49:

a) Detectability limit: 1/2 fiberglass filter.....

b) Withdrawn therefrom

c) Lead content of 1/2 fiberglass filter: From the ascertained extinc tions minus blank value the lead content of 1/2 fiberglass filter amounts to 17.6 ug (e.g.....) and at a weight of 1.67 g for 1/2 fiberglass filter it amounts to 10.5 ug Pb/g fiberglass filter. This result agrees well with the shaking out of 1 g of fiberglass filter.

d) Threshold value....

e) Detectability limit.....

Key to Appendix 6 page 50:

a) Lead content of acid extract of 1 g fiberglass filter

a Eichkurve: 1/2 Glasfaserfilter (GFF) + a µg Pb in 250 ml. Anlage 4

| vorgelegt davon entnommen b | 1/2 GFF + 50 µg Pb/250 ml 50 ml = 10 µg Pb | | | 1/2 GFF + 100 µg Pb/250 ml 50 ml = 20 µg Pb | | | 1/2 GFF + 200 µg Pb/250 ml 50 ml = 40 µg Pb | | | 1/2 GFF + 300 µg Pb/250 ml 50 ml = 60 µg Pb | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ |
| 1) | 0,201 | 21 | 441 | 0,290 | 16 | 256 | 0,555 | 3 | 9 | 0,792 | 17 | 289 |
| 2) | 0,195 | 15 | 225 | 0,320 | 14 | 196 | 0,553 | 5 | 25 | 0,815 | 6 | 36 |
| 3) | 0,179 | 1 | 1 | 0,308 | 2 | 4 | 0,569 | 11 | 121 | 0,795 | 14 | 196 |
| 4) | 0,178 | 2 | 4 | 0,306 | — | — | 0,571 | 13 | 169 | 0,797 | 12 | 144 |
| 5) | 0,173 | 7 | 49 | 0,310 | 4 | 16 | 0,552 | 6 | 36 | 0,802 | 7 | 49 |
| 6) | 0,170 | 10 | 100 | 0,319 | 13 | 169 | 0,549 | 9 | 81 | 0,814 | 5 | 25 |
| 7) | 0,180 | — | — | 0,311 | 5 | 25 | 0,552 | 6 | 36 | 0,816 | 7 | 49 |
| 8) | 0,179 | 1 | 1 | 0,297 | 9 | 81 | 0,570 | 12 | 144 | 0,820 | 11 | 121 |
| 9) | 0,171 | 9 | 81 | 0,305 | 1 | 1 | 0,555 | 3 | 9 | 0,809 | — | — |
| 10) | 0,174 | 6 | 36 | 0,294 | 12 | 144 | 0,554 | 4 | 16 | 0,828 | 19 | 361 |
| $\Sigma$ | 1,800 | | 938 : 9 | 3,060 | | 892 : 9 | 5,581 | | 649 : 9 | 8,088 | | 1270 : 9 |
| $\bar{x}$ | 0,180 | | = 104,2 | 0,306 | | = 99,1 | 0,558 | | = 71,8 | 0,809 | | = 141 |
| $\sigma$ | 0,0104 | | | 0,010 | | | 0,0085 | | | 0,0118 | | |
| $\sigma_{rel}$ | 5,7 % | | | 3,3 % | | | 1,6 % | | | 1,5 % | | |
| $\bar{x}$—Bl | 0,120 · 80,6 = 9,7 µg Pb | | | 0,246 · 80,6 = 19,8 µg Pb | | | 0,498 · 80,6 = 40,1 µg Pb | | | 0,749 · 80,6 = 60,3 µg Pb | | |
| c Eichfaktor: | 10 : 0,120 = 83,3 | | | 20 : 0,246 = 81,3 | | | 40 : 0,498 = 80,3 | | | 60 : 0,749 = 80,2 | | |
| d Richtungsfaktor: | 0,0120 | | | 0,0123 | | | 0,0127 | | | 0,0125 | | |

e Mittlerer Eichfaktor: aus 20, 40 und 60 µg Pb = 80,6.

f Mittlerer Richtungsfaktor: aus 20, 40 und 60 µg Pb = 0,0125.

(See page 47 for key)

a Nachweisbarkeitsgrenze: 1/2 Glasfaserfilter (GFF) Schleicher und Schüll Nr. 9 auf 250 ml.

| davon entnommen | 25 ml = 1/10 | | | 50 ml = 1/5 | | | 100 ml = 2/5 | | |
|---|---|---|---|---|---|---|---|---|---|
| b | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ |
| 1) | 0,047 | 5 | 25 | 0,063 | 3 | 9 | 0,100 | 7 | 49 |
| 2) | 0,040 | 2 | 4 | 0,065 | 5 | 25 | 0,088 | 19 | 361 |
| 3) | 0,032 | 10 | 100 | 0,063 | 3 | 9 | 0,110 | 3 | 9 |
| 4) | 0,034 | 8 | 64 | 0,070 | 10 | 100 | 0,118 | 11 | 121 |
| 5) | 0,040 | 2 | 4 | 0,058 | 2 | 4 | 0,117 | 10 | 100 |
| 6) | 0,040 | 2 | 4 | 0,050 | 10 | 100 | 0,103 | 4 | 16 |
| 7) | 0,047 | 5 | 25 | 0,057 | 3 | 9 | 0,104 | 3 | 9 |
| 8) | 0,047 | 5 | 25 | 0,052 | 8 | 64 | 0,100 | 7 | 49 |
| 9) | 0,048 | 6 | 36 | 0,070 | 10 | 100 | 0,109 | 2 | 4 |
| 10) | 0,046 | 4 | 16 | 0,050 | 10 | 100 | 0,122 | 15 | 225 |
| $\Sigma$ | 0,421 | | 323 : 9 | 0,598 | | 523 : 9 | 1,071 | | 943 : 9 |
| $\bar{x}$ | 0,042 | | = 33,7 | 0,060 | | = 57,7 | 0,107 | | = 105,0 |
| $\sigma$ | 0,0058 | | | 0,0076 | | | 0,0104 | | |
| $\sigma_{v.t}$ | 13,6 % | | | 12,6 % | | | 9,7 % | | |

d Schwellenwert

| | | | |
|---|---|---|---|
| $\bar{x} + 3\sigma$ | 0,042 + (3 · 0,006) = 0,060 | 0,060 + (3 · 0,0076) = 0,083 | 0,107 + 3 (0,0104) = 0,138 |
| µg Pb | 4,8 | 6,7 | 11,1 |
| µg Pb 250 ml | 48,0 | 33,5 | 27,7 |

e Nachweisbarkeitsgrenze 1 h 80 m³/h: 1,2 µg Pb | 0,8 µg Pb | 0,7 µg Pb

c **Bleigehalt von 1/2 GGF:** Aus den ermittelten Extinktionen abzüglich Blindwert errechnet sich der Bleigehalt von 1/2 GFF zu 17,6 µg (z. B.: 0,088 · 2,5 = 80,6 − 17,6) und bei einem Gewicht des halben GFF von 1,67 g zu 10,5 µg Pb/g GFF. Dieses Ergebnis stimmt gut mit den direkten Ausschüttelungen von 1 g GFF überein.

(See page 47 for key)

Anlage 6

a Bleigehalt des Säureauszuges von 1 g Glasfaserfilter (GFF).

| Schleicher und Schüll Nr. 9 | | | | Gessner L 60 | | | |
|---|---|---|---|---|---|---|---|
| | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ | | $E_{x_i}$ | A $(x_i-\bar{x})\cdot 10^3$ | B $A^2$ |
| 1) | 0,154 | 5 | 25 | 1) | 0,178 | 7 | 49 |
| 2) | 0,161 | 12 | 144 | 2) | 0,173 | 2 | 4 |
| 3) | 0,146 | 3 | 9 | 3) | 0,160 | 11 | 121 |
| 4) | 0,160 | 11 | 121 | 4) | 0,159 | 12 | 144 |
| 5) | 0,150 | 1 | 1 | 5) | 0,176 | 5 | 25 |
| 6) | 0,140 | 9 | 81 | 6) | 0,171 | — | — |
| 7) | 0,143 | 6 | 36 | 7) | 0,163 | 8 | 64 |
| 8) | 0,153 | 4 | 16 | 8) | 0,161 | 10 | 100 |
| 9) | 0,151 | 2 | 4 | 9) | 0,167 | 4 | 16 |
| 10) | 0,141 | 8 | 64 | 10) | 0,174 | 3 | 9 |
| 11) | 0,140 | 9 | 81 | 11) | 0,180 | 9 | 81 |
| 12) | 0,152 | 3 | 9 | 12) | 0,170 | 1 | 1 |
| $\Sigma$ | 1,791 | | 591 : 11 = 53,7 | $\Sigma$ | 2,032 | | 614 : 11 = 55,7 |
| $\bar{x}$ | 0,149 | | | $\bar{x}$ | 0,171 | | |
| $\sigma$ | 0,0073 | | | $\sigma$ | 0,0075 | | |
| $\sigma_{rel}$ | 4,9 % | | | $\sigma_{rel}$ | 4,4 % | | |

$E_{x_i} - E_{Bl} = 0{,}130 \cdot 80{,}6$
$= 10{,}5\ \mu g$ Pb/g GFF

$E_{x_i} - E_{Bl} = 0{,}152 \cdot 80{,}6$
$= 12{,}2\ \mu g$ Pb/g GFF

(See page 47 for key)

Key to Appendix 7 page 52:

a) MÜLHEIM (RUHR). Lead content of the atmosphere....

b) Designation of measuring points

c) Type of measuring point

d) Average vehicle density/h

e) µg of lead per $m^3$

f) Average

1) .....Residential/industrial area

2).....Large crossing

3).....Main thoroughfare

4) At the racetrack open, spacious terrain

5) .....Residential area

6) Center of town large square, several streets

7) Railroad station Mülheim (Ruhr) Forecourt Narrow place

8) .....Large square, few houses

9) .....Dwellings on both sides

10)...School Residential area. very slight

11) .....Open terrain

12) .....Wooded area no traffic

g) Daily average

Key to Appendix 8 page 53:

a) DÜSSELDORF. Lead content of the atmosphere.....

b) Designation of measuring point

c) Type of measuring point

d) Average vehicle density/h

e) µg of lead per $m^3$

a Mülheim (Ruhr). Bleigehalt der atmosphärischen Luft in µg/m³. Anlage 7

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e µg Blei je m³ 14.9. 1965 | 27.9. 1965 | 11.10. 1965 | 20.10. 1965 | 8.11. 1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Mellinghofer Straße/ Zehntweg | Wohn-/Industriegebiet | 580 | 9,6 | 2,3 | 8,4 | 3,3 | 1,3 | 5,0 |
| 2 | Prinzeß-Luise-Straße/ Saarner Straße | große Kreuzung | 310 | 7,3 | 4,5 | 10,8 | 4,7 | 3,1 | 6,1 |
| 3 | Duisburger Straße/ Liebigstraße | Hauptverkehrsstraße | 530 | 3,6 | 5,1 | 5,3 | 1,6 | 1,3 | 3,4 |
| 4 | An der Rennbahn | offenes, weites Gelände | 380 | 2,7 | 1,4 | 4,4 | 2,0 | 1,2 | 2,3 |
| 5 | Oberhausener Straße/ Dümptener Straße | Wohngebiet | 230 | 2,8 | 1,1 | 5,0 | 3,9 | 1,8 | 2,9 |
| 6 | Stadtmitte, Leineweberstraße/Friedrich-Ebert-Str. | großer Platz, mehrere Straßen | 1310 | 4,0 | 1,4 | 10,4 | 10,2 | 1,8 | 5,6 |
| 7 | Bahnhof Mülheim (Ruhr), Vorplatz | enger Platz | 640 | 3,2 | 2,0 | 8,2 | 4,4 | 3,9 | 4,3 |
| 8 | Zeppelinstraße/ Obere Saarlandstraße | großer Platz, wenig Häuser | 730 | 4,0 | 0,8 | 6,7 | 4,0 | 0,6 | 4,4 |
| 9 | Aktienstraße/ Mellinghofer Straße | beiderseits Wohngebäude | 300 | 4,9 | 4,5 | 6,2 | 4,8 | 3,7 | 4,8 |
| 10 | Schildberg, Schule | Wohngebiet | sehr gering | 10,5 | 3,1 | 2,3 | 3,2 | 1,3 | 4,1 |
| 11 | Aktienstraße Daimlerstraße | freies Gelände | 530 | 4,7 | 1,0 | 9,0 | 3,8 | 0,6 | 3,8 |
| 12 | Freundhof | Waldgebiet | kein Verkehr | 2,9 | 5,2 | 3,4 | 2,8 | 1,3 | 3,2 |
| | g | Tagesmittel | | 5,0 | 2,7 | 6,7 | 4,1 | 1,8 | |

(See page 51 for key)

a **Düsseldorf.** Bleigehalt der atmosphärischen Luft in $\mu g/m^3$. **Anlage 8**

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e $\mu$g Blei je m³ 21.9. 1965 | 14.10. 1965 | 28.10. 1965 | 11.11. 1965 | 25.11. 1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Hennekamp/Witzelstraße | große, offene Kreuzung | 1140 | 6,0 | 1,9 | 3,3 | 2,2 | 2,1 | 3,1 |
| 2 | Werstener Kreuz | enge Straße, Durchgangsverkehr | 1000 | 2,5 | 4,5 | 7,3 | 4,7 | 3,1 | 4,4 |
| 3 | Graf-Adolf-Platz, Busbahnhof | weiter Platz, Zentrum | 1160 | 2,5 | 4,7 | 3,0 | 4,0 | 4,5 | 3,7 |
| 4 | Hauptbahnhof | weiter Platz, Zentrum | 100 | 5,4 | 1,8 | 2,7 | 2,0 | — | 3,0 |
| 5 | Grafenberger Allee/ Lindemannstraße | große Kreuzung, Durchgangsverkehr | 1030 | 2,3 | — | 2,9 | 5,3 | 3,4 | 3,5 |
| 6 | Rather Kreuzweg/ Westfalenstraße | enge Straße | 610 | 4,4 | 2,2 | 1,3 | 1,0 | 0,8 | 1,9 |
| 7 | Ulmenstraße/Glockenstraße | enge Straße | 480 | 4,1 | 4,4 | 3,8 | 1,7 | 3,3 | 3,5 |
| 8 | Oberkasseler Brücke | sehr verkehrsreich | 1690 | 4,1 | 3,4 | 2,5 | 0,7 | 2,7 | 2,7 |
| 9 | Stockumer Kirchstraße/ Kaiserswerther Straße | weite, offene Kreuzung | 360 | 3,6 | 4,0 | 3,5 | 1,9 | 1,2 | 2,8 |
| 10 | Rennbahngelände | offenes, begrüntes Feld | kein Verkehr | 3,5 | 1,4 | — | — | — | — |
| | g | Tagesmittel | | 3,8 | 3,1 | 3,4 | 2,6 | 2,5 | |

(See page 51 and 54 for key)

Key to Appendix 8 page 53 continued:

f) Average

1) .....Large, open crossing

2) .....Narrow street, through traffic

3) .....
Bus Terminal Large square, center of town

4) Main Rail-
road Station Large square, center of town

5) .....Large crossing, through traffic

6) .....Narrow street

7) .....Narrow street

8) .....
Bridge Much traffic

9) .....Large, open crossing

10) Racetrack
terrain Open, grass-covered field no traffic

g) Daily average

Key to Appendix 9 page 55:

a) NEUB ON THE RHEIN. Lead content of atmosphere .....

b) Designation of measuring point

c) Type of measuring point

d) Average vehicle density/h

e) µg of lead per $m^3$ f) Average

1) .....Main Street, residential area

2) .....Thoroughfare

3) .....
City Hall One-way street, lively traffic

4) Harbor, Industrial area

a Neuß am Rhein. Bleigehalt der atmosphärischen Luft in µg/m³. Anlage 9

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/$h_d$ | e µg Blei je m³ 15.9.1965 | 12.10.1965 | 26.10.1965 | 9.11.1965 | 23.11.1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Reuschenberg, Bergheimer Straße 481 | Hauptstraße, Wohngebiet | 360 | 4,5 | 3,9 | 1,5 | 1,0 | — | 2,8 |
| 2 | Obertor 19 | Durchgangsstraße | 290 | 7,9 | 4,1 | 3,2 | 1,1 | 1,8 | 3,6 |
| 3 | Markt (Rathaus) | Einbahnstraße, reger Verkehr | 440 | 8,1 | 3,4 | 2,1 | 2,1 | 2,8 | 3,7 |
| 4 | Hafen, Hammer Landstraße | Industriegebiet | 280 | 6,6 | 1,2 | 1,8 | 2,5 | 5,2 | 3,5 |
| 5 | Drususallee, Kindergarten | Fahrbahn getrennt | 230 | 4,1 | 0,6 | 1,8 | 0,9 | 1,1 | 1,7 |
| 6 | Krefelder Straße/ Theodor-Heuss-Platz | Hauptverkehrspunkt | 670 | 12,5 | 1,8 | 6,9 | 5,8 | 9,0 | 7,2 |
| 7 | Kaarster Straße/ Gladbacher Straße | starke Frequenz | 430 | 5,8 | 3,0 | 2,9 | 2,1 | 4,2 | 3,6 |
| 8 | Berliner Platz/Further Straße | Wohngebiet, Parkplatz | 380 | 3,4 | 1,4 | 5,3 | 1,4 | 4,6 | 3,2 |
| 9 | Friedrich-Ebert-Platz | große Kreuzung, Grünanlage | 380 | 4,9 | 3,8 | 2,9 | 2,7 | — | 3,3 |
| 10 | Gesundheitsamt, Carossastraße | offener Platz, Wohngebiet | geringer Verkehr | 4,4 | 0,9 | 1,6 | 0,7 | 2,6 | 2,0 |
| | g | Tagesmittel | | 5,1 | 2,4 | 3,0 | 2,0 | 3,9 | |

(See page 54 and 56 for key)

Key to Appendix 9 page 55 continued:

5) .....Roads separated

6) .....Main traffic junction

7) .....Heavily frequented

8) .....Residential area, park area

9) .....large crossing, gardens

10) .....Open space, residential area slight traffic

g) Daily average

Key to Appendix 10 page 57:

a) DUISBURG. Lead content of atmosphere....

b) Designation of measuring point

c) Type of measuring point

d) Average vehicle density/h

e) ug of lead per $m^3$

f) Average

1) .....Industrial area

2) .....Mixed area

3) .....Residential area, dense traffic

4) .....Open terrain

5) .....Large street crossing

6) .....Residential area

7) .....Large crossing, busy

8) .....Center of town

9) .....Residential area on park

10) .Beach Hardly any traffic

g) Daily average

a **Duisburg.** Bleigehalt der atmosphärischen Luft in µg/m³. **Anlage 10**

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e µg Blei je m³ 23.9.1965 | 13.10.1965 | 27.10.1965 | 10.11.1965 | 24.11.1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Ehingerstraße/ Steinbrinkstraße | Industriegegend | 90 | 2,8 | 1,9 | 1,9 | 1,1 | 7,0 | 2,9 |
| 2 | Düsseldorfer Straße/ Kulturstraße | gemischte Gegend | 1290 | 3,6 | 2,9 | 3,0 | 1,6 | 2,0 | 2,6 |
| 3 | Alt Hamborn, Duisburger Straße/Alleestraße | Wohngebiet, dichter Verkehr | 930 | 5,0 | 7,0 | — | — | — | 6,0 |
| 4 | Sternbuschweg/Hertzstraße | offenes Gelände | 340 | 6,1 | 5,1 | 3,3 | 0,6 | 0,7 | 3,2 |
| 5 | Sternbuschweg/ Mülheimer Straße | große Straßenkreuzung | 890 | 2,7 | 3,2 | 1,9 | 1,4 | 1,7 | 2,1 |
| 6 | Nordtunnel/Mühlenstraße | Wohngegend | 260 | 7,9 | 11,0 | 10,2 | 2,0 | 2,6 | 6,7 |
| 7 | Rheinhauser Straße/ Heerstraße | große Kreuzung, rege | 1060 | 6,3 | 3,0 | 2,9 | 2,5 | 4,0 | 3,7 |
| 8 | Königstraße/ Düsseldorfer Straße | Stadtzentrum | 680 | 6,3 | 3,9 | 3,7 | 2,6 | 3,6 | 4,0 |
| 9 | Bürgermeister-Pütz-Straße/ Gabelsberger Straße | Wohnviertel am Park | 280 | 8,9 | 5,4 | 3,0 | 2,6 | — | 5,0 |
| 10 | Wedau, Strandbad | kaum Verkehr | — | 2,3 | 3,3 | 1,3 | 0,6 | 0,8 | 1,7 |
| | g | Tagesmittel | | 5,1 | 4,7 | 3,5 | 1,7 | 2,8 | |

(See page 56 for key)

Key to Appendix 11 page 52:

a) WUPPERTAL. Lead content of the atmosphere .....

b) Designation of measuring point

c) Type of measuring point

d) Average vehicle density/h

e) ug of lead per $m^3$

f) Average

1) ..... Densely populated area

2) ..... Densely populated area

3) Railroad
Terminal Forecourt

4) ..... Main thorough drive

5) ..... Residential area

6) ..... Residential area

7) ..... In yard (Civil Engineering Office)

8) ..... Lightly settled residential area

9) ..... No traffic

g) Daily average

Key to Appendix 12 page 60:

a) MULHEIM/RUHR. Suspended dust in the air in streets at 1 m elevation.

b) Designation of measuring points

c) Type of measuring point

d) Average vehicle density/h

e) mg of dust/$m^3$

f) Average

1) ..... Residential/Industrial area

a Wuppertal. Bleigehalt der atmosphärischen Luft in $\mu g/m^3$. Anlage 11

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e $\mu g$ Blei je $m^3$ 16.9.1965 | 7.10.1965 | 25.10.1965 | 15.11.1965 | 15.12.1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Friedrich-Ebert-Straße/ Varresbecker Straße | dicht besiedeltes Gebiet | 820 | 4,8 | 10,0 | 3,8 | 7,4 | 3,4 | 5,9 |
| 2 | Neumarkt | dicht besiedeltes Gebiet | 1050 | 0,8 | 2,3 | 6,0 | 2,2 | 2,6 | 2,6 |
| 3 | Bahnhof | Vorplatz | 700 | 3,4 | 3,4 | 1,8 | 3,1 | 2,7 | 2,9 |
| 4 | Friedrich-Engels-Allee, Post | Hauptverkehrsstraße | 590 | 2,8 | 3,4 | 2,5 | 2,2 | 2,9 | 2,7 |
| 5 | Uellendahler Straße/ Wiesenstraße | Wohngegend | 950 | 1,3 | 9,0 | 8,1 | 6,9 | 3,4 | 6,7 |
| 6 | Schönebecker Straße/ Sandstraße | Wohngegend | 490 | 3,7 | 2,8 | 1,9 | 2,5 | 2,5 | 2,7 |
| 7 | Klingelholl, Tiefbauamt | im Hof | 310 | 1,5 | 4,6 | 3,8 | 2,8 | 4,5 | 3,4 |
| 8 | Langenfelder Straße/ Rauentaler Bergstraße | lichtes Wohngebiet | 240 | 0,8 | 3,0 | 0,5 | 9,8 | 1,3 | 3,1 |
| 9 | Burgholz | | kein Verkehr | 0,6 | 0,7 | 0,2 | 0,4 | 0,6 | 0,5 |
| | g | Tagesmittel | | 2,2 | 4,3 | 3,2 | 4,1 | 2,7 | |

(See page 58 for key)

a Mülheim/Ruhr. Schwebestaubgehalt der atmosphärischen Luft in den Straßen in 1 m Höhe. Anlage 12

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e mg Staub/m³ 14.9. 1965 | 27.9. 1965 | 11.10. 1965 | 20.10. 1965 | 8.11. 1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Mellinghofer Straße/ Zehntweg | Wohn-/Industriegebiet | 580 | 0,80 | 0,37 | 1,15 | 0,77 | 0,26 | 0,67 |
| 2 | Prinzeß-Luise-Straße/ Saarner Straße | große Kreuzung | 310 | 0,86 | 0,35 | 1,39 | 0,70 | 0,38 | 0,74 |
| 3 | Duisburger Straße/ Liebigstraße | Hauptverkehrsstraße | 530 | 0,30 | 0,81 | 0,65 | 0,38 | 0,35 | 0,50 |
| 4 | An der Rennbahn | offenes, weites Gelände | 380 | 0,23 | 0,34 | 0,63 | 0,38 | 0,19 | 0,35 |
| 5 | Oberhausener Straße/ Dümptener Straße | Wohngebiet | 230 | 0,38 | 0,66 | 1,03 | 0,87 | 0,71 | 0,73 |
| 6 | Stadtmitte, Leineweberstraße, Friedrich-Ebert-Str. | großer Platz, mehrere Straßen | 1310 | 0,38 | 0,42 | 1,42 | 1,48 | 0,38 | 0,82 |
| 7 | Bahnhof Mülheim (Ruhr), Bahnhofsvorplatz | enger Platz | 640 | 0,43 | 0,31 | 1,47 | 0,67 | 0,81 | 0,74 |
| 8 | Zeppelinstraße/ Obere Saarlandstraße | großer Platz, wenig Häuser | 730 | 0,44 | 0,14 | 0,62 | 0,47 | 0,19 | 0,37 |
| 9 | Aktienstraße/ Mellinghofer Straße | beiderseits Wohngebäude | 300 | 0,31 | 0,72 | 0,37 | 0,80 | 0,91 | 0,62 |
| 10 | Schildberg, Schule | Wohngebiet | sehr gering | 0,42 | 0,76 | 0,81 | 0,40 | 0,40 | 0,56 |
| 11 | Aktienstraße/Daimlerstraße | freies Gelände | 530 | 0,50 | 0,47 | 1,40 | 1,04 | 0,15 | 0,71 |
| 12 | Freundhof | Waldgebiet | kein Verkehr | 0,30 | 0,17 | 0,45 | 0,22 | 0,14 | 0,27 |
| | g | Tagesmittel | | 0,45 | 0,61 | 0,95 | 0,68 | 0,40 | |

(See page 58 and 61 for key)

Key to Appendix 12 page 60 continued:

| | | | |
|---|---|---|---|
| 2) | ..... | Large crossing | |
| 3) | ..... | Main thoroughfare | |
| 4) | At race-track | Wide-open terrain | |
| 5) | ..... | Residential area | |
| 6) | Center of town | Large square, several streets | |
| 7) | Railroad Terminal Forecourt | Narrow place | |
| 8) | ..... | Large square, few houses | |
| 9) | ..... | Residential buildings on both sides | |
| 10) | ..School | Residential area | Very slight |
| 11) | ..... | Open terrain | |
| 12) | ..... | Wooded area | No traffic |

g) Daily average

Key to Appendix 13 page 62:

a) DÜSSELDORF. Suspended dust in the air in streets at 1 m elevation

b) Designation of measuring points

c) Type of measuring point

d) Average vehicle density/h

e) mg of dust/$m^3$

f) Average

| | | |
|---|---|---|
| 1) | ..... | Large, open crossing |
| 2) | ..... | Narrow street, through traffic |
| 3) | ...Bus Terminal | Large square, center of town |

a **Düsseldorf.** Schwebestaubgehalt der atmosphärischen Luft in den Straßen in 1 m Höhe. **Anlage 13**

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e mg Staub/m³ 21.9. 1965 | 14.10. 1965 | 28.10. 1965 | 11.11. 1965 | 25.11. 1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Hennekamp/Witzelstraße | große, offene Kreuzung | 1140 | — | 0,54 | 0,53 | 0,21 | 0,41 | 0,42 |
| 2 | Werstener Kreuz | enge Straße, Durchgangsverkehr | 1000 | 1,29 | 1,15 | 1,44 | 0,34 | 0,42 | 0,93 |
| 3 | Graf-Adolf-Platz, Busbahnhof | weiter Platz, Zentrum | 1160 | 0,50 | 0,86 | 0,46 | 0,16 | 0,82 | 0,36 |
| 4 | Hauptbahnhof | weiter Platz, Zentrum | 100 | 0,48 | 0,50 | 0,40 | 0,17 | — | 0,39 |
| 5 | Grafenberger Allee/ Lindemannstraße | große Kreuzung, Durchgangsverkehr | 1030 | 0,85 | — | 0,61 | 0,31 | 0,65 | 0,60 |
| 6 | Rather Kreuzweg/ Westfalenstraße | enge Straße | 610 | 0,34 | 0,65 | 0,49 | 0,18 | 0,38 | 0,41 |
| 7 | Ulmenstraße/Glockenstraße | enge Straße | 480 | 0,50 | 0,95 | 0,80 | 0,19 | 0,55 | 0,60 |
| 8 | Oberkasseler Brücke | sehr verkehrsreich | 1690 | 0,63 | 0,69 | 0,55 | 0,13 | 0,47 | 0,49 |
| 9 | Stockumer Kirchstraße/ Kaiserswerther Straße | weite, offene Kreuzung | 360 | 0,49 | 0,92 | 1,40 | 0,33 | 0,20 | 0,67 |
| 10 | Rennbahngelände | offenes, begrüntes Feld | kein Verkehr | 0,34 | 0,43 | — | — | 0,29 | 0,35 |
| | g | Tagesmittel | | 0,60 | 0,74 | 0,73 | 0,22 | 0,42 | |

(See page 61 and 63 for key)

Key to Appendix 13 page 62 continued:

| | | | |
|---|---|---|---|
| 4) | Main Railroad Station ..... | Large square, center of town | |
| 5) | ..... | Large crossing, through traffic | |
| 6) | ..... | Narrow street | |
| 7) | ..... | Narrow street | |
| 8) | ....Bridge | Heavy traffic | |
| 9) | ..... | Large, open crossing | |
| 10) | Racetrack terrain | Open, grass-covered field | no traffic |

g) Daily average

Key to Appendix 14 page 64:

a) NEUß ON THE RHEIN. Content of suspended atmospheric dust in streets at 1 m elevation

b) Designation of measuring points

c) Type of measuring points

d) Average vehicle density/h

e) mg of dust/$m^3$

f) Average

| | | |
|---|---|---|
| 1) | ..... | Main street, residential area |
| 2) | ..... | Thoroughfare |
| 3) | ...City Hall | One-way street, lively traffic |
| 4) | Harbor, .... | Industrial area |
| 5) | ..... | Divided roads |
| 6) | ..... | Main traffic junction |
| 7) | ..... | Heavily frequented |
| 8) | ..... | Residential area, park area |

a **Neuß am Rhein.** Schwebestaubgehalt der atmosphärischen Luft in den Straßen in 1 m Höhe. **Anlage 14**

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e mg Staub/m³ 15.9.1965 | 12.10.1965 | 26.10.1965 | 9.11.1965 | 23.11.1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Reuschenberg, Bergheimer Straße 481 | Hauptstraße, Wohngebiet | 360 | 0,65 | 0,53 | 0,43 | 0,31 | — | 0,48 |
| 2 | Obertor 19 | Durchgangsstraße | 290 | 0,80 | 1,25 | 0,80 | 0,53 | 0,43 | 0,77 |
| 3 | Markt (Rathaus) | Einbahnstraße, reger Verkehr | 440 | 0,73 | 0,50 | 0,47 | 0,53 | 0,80 | 0,61 |
| 4 | Hafen, Hammer Landstraße | Industriegebiet | 280 | 0,63 | 0,56 | 0,40 | 0,65 | 0,66 | 0,58 |
| 5 | Drususallee, Kindergarten | Fahrbahn getrennt | 230 | 0,32 | 0,45 | 0,46 | 0,32 | 0,34 | 0,38 |
| 6 | Krefelder Straße/ Theodor-Heuss-Platz | Hauptverkehrspunkt | 670 | 1,32 | 1,05 | 0,91 | 0,81 | 1,72 | 1,16 |
| 7 | Kaarster Straße/ Gladbacher Straße | starke Frequenz | 430 | 0,67 | 0,56 | 0,67 | 0,51 | 1,00 | 0,68 |
| 8 | Berliner Platz/Further Straße | Wohngebiet, Parkplatz | 380 | 0,41 | 0,52 | 0,58 | 0,34 | 0,83 | 0,54 |
| 9 | Friedrich-Ebert-Platz | große Kreuzung, Grünanlage | 380 | 0,43 | 0,60 | 0,53 | 0,58 | — | 0,54 |
| 10 | Gesundheitsamt, Carossastraße | offener Platz, Wohngebiet | geringer Verkehr | 0,29 | 0,37 | 0,46 | 0,16 | 0,37 | 0,33 |
| | g | Tagesmittel | | 0,63 | 0,64 | 0,57 | 0,47 | 0,79 | |

(See page 63 and 65 for key)

Key to Appendix 14 page 64 continued:

9) ..... Large crossing, gardens

10) Board of Health Open square, residential area Little traffic

g) Daily average

Key to Appendix 15 page 66:

a) DUISBURG. Content of suspended atmospheric dust in streests at 1 m

b) Designation of measuring points

c) Type of measuring points

d) Average vehicle density/h

e) mg of dust/$m^3$

f) Average

1) ..... Industrial area

2) ..... Large mixed area

3) ..... Residential area

4) ..... Open

5) ..... Large crossing, open

6) ..... Residential area

7) ..... Large crossing, lively traffic

8) ..... Center of town

9) ..... Residential area at park

10) ..Beach Edge of municipal park

g) Daily average

Key to Appendix 16 page 67:

a) WUPPERTAL. Content of suspended atmospheric dust in streets at 1 m elevation

a **Duisburg. Schwebestaubgehalt der atmosphärischen Luft in den Straßen in 1 m Höhe.** **Anlage 15**

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e mg Staub/m³ 23.9. 1965 | 10.10. 1965 | 27.10. 1965 | 10.11. 1965 | 24.11. 1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Ehingerstraße/ Steinbrinkstraße | Industriegegend | 90 | 0,49 | 0,57 | 0,32 | 0,21 | 0,54 | 0,43 |
| 2 | Düsseldorfer Straße/ Kulturstraße | weiträumig gemischte Gegend | 1290 | 0,44 | 0,62 | 0,72 | 0,28 | 0,53 | 0,52 |
| 3 | Alt Hamborn, Duisburger Straße/ Alleestraße | Wohngebiet | 930 | 0,48 | 0,87 | — | — | — | 0,67 |
| 4 | Sternbuschweg/ Hertzstraße | offen | 340 | 0,86 | 0,74 | 0,61 | 0,19 | 0,29 | 0,54 |
| 5 | Sternbuschweg/ Mülheimer Straße | große Kreuzung, offen | 890 | 0,35 | 0,42 | 0,40 | 0,21 | 0,15 | 0,31 |
| 6 | Nordtunnel Mühlenstraße | Wohngegend | 260 | 1,12 | 1,04 | 1,08 | 0,50 | 0,38 | 0,82 |
| 7 | Rheinhauser Straße/ Heerstraße | große Kreuzung, reger Verkehr | 1060 | 1,49 | 0,63 | 0,45 | 0,46 | 0,16 | 0,60 |
| 8 | Königstraße/ Düsseldorfer Straße | Stadtzentrum | 680 | 0,48 | 0,59 | 0,48 | 0,42 | 0,31 | 0,46 |
| 9 | Bürgermeister-Pütz-Straße/ Gabelsberger Straße | Wohnviertel am Park | 280 | 0,59 | 0,64 | 0,56 | 0,37 | — | 0,54 |
| 10 | Wedau, Strandbad | Stadtwaldrand | kaum | 0,30 | 0,40 | 0,33 | 0,27 | 0,29 | 0,32 |
| | g | Tagesmittel | | 0,67 | 0,64 | 0,55 | 0,32 | 0,33 | |

(See page 65 for key)

a **Wuppertal.** Schwebestaubgehalt der atmospärischen Luft in den Straßen in 1 m Höhe. **Anlage 16**

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e mg Staub/m³ 19.6. 1965 | 7.10. 1965 | 25.10. 1965 | 18.11. 1965 | 15.12. 1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Friedrich-Ebert-Straße/ Varresbecker Straße | dicht besiedeltes Gebiet | 820 | 1,15 | 1,70 | 1,52 | 0,48 | 1,69 | 1,31 |
| 2 | Neumarkt | dicht besiedeltes Gebiet | 1050 | 0,29 | 0,56 | 0,91 | 0,19 | 0,42 | 0,47 |
| 3 | Bahnhof | Vorplatz | 700 | 0,58 | 0,44 | 0,55 | 0,20 | 0,77 | 0,51 |
| 4 | Friedrich-Engels-Allee, Post | Hauptverkehrsstraße | 590 | 0,75 | 1,04 | 0,97 | 0,20 | 0,54 | 0,50 |
| 5 | Uellendahler Straße/ Wiesenstraße | Wohngegend | 950 | 0,32 | 0,82 | 0,70 | 0,25 | 0,41 | 0,50 |
| 6 | Schönebecker Straße/ Sandstraße | Wohngegend | 490 | 0,52 | 0,85 | 0,56 | 0,37 | 1,18 | 0,69 |
| 7 | Klingelholl, Tiefbauamt | im Hof | 310 | 0,35 | 0,98 | 1,04 | 0,27 | 1,60 | 0,85 |
| 8 | Langenfelder Straße/ Rauentaler Bergstraße | lichtes Wohngebiet | 240 | 0,35 | 0,89 | 0,29 | 0,20 | 0,70 | 0,48 |
| 9 | Burgholz | | kein Verkehr | 0,11 | 0,17 | 0,12 | 0,10 | 0,14 | 0,13 |
| | g Tagesmittel | | | 0,49 | 0,72 | 0,74 | 0,25 | 0,83 | |

See page 65 and 68 for key)

a **Mülheim (Ruhr). Bleianteil im Schwebestaub in Prozent.** **Anlage 17**

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e % Blei im Staub 14.9. 1965 | 27.9. 1965 | 11.10. 1965 | 20.10. 1965 | 8.11. 1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Mellinghofer Straße/ Zehntweg | Wohn-/Industriegebiet | 580 | 1,2 | 0,6 | 0,7 | 0,4 | 0,5 | 0,7 |
| 2 | Prinzeß [illegible]aise-Straße/ Saarner Straße | große Kreuzung | 310 | 0,9 | 1,3 | 0,8 | 0,7 | 0,8 | 0,9 |
| 3 | Duisburger Straße/ Liebigstraße | Hauptverkehrsstraße | 530 | 1,2 | 0,6 | 0,8 | 0,4 | 0,4 | 0,7 |
| 4 | An der Rennbahn | offenes, weites Gelände | 380 | 1,2 | 0,4 | 0,7 | 0,5 | 0,6 | 0,7 |
| 5 | Oberhausener Straße/ Dumptener Straße | Wohngebiet | 230 | 0,7 | 0,2 | 0,5 | 0,4 | 0,3 | 0,4 |
| 6 | Stadtmitte, Leineweberstraße/Friedrich-Ebert-Str. | großer Platz, viele Straßen | 1310 | 1,1 | 0,3 | 0,7 | 0,7 | 0,5 | 0,6 |
| 7 | Bahnhof Mülheim (Ruhr), Bahnhofsvorplatz | enger Platz | 640 | 0,7 | 0,6 | 0,6 | 0,7 | 0,5 | 0,6 |
| 8 | Zeppelinstraße/ Obere Saarlandstraße | großer Platz, wenig Häuser | 730 | 0,9 | 0,6 | 1,1 | 0,9 | 0,3 | 0,8 |
| 9 | Aktienstraße/ Mellinghofer Straße | beiderseits Wohngebäude | 300 | 1,6 | 0,6 | 1,7 | 0,6 | 0,4 | 1,0 |
| 10 | Schildberg, Schule | Wohngebiet | sehr gering | 2,5 | 0,4 | 0,3 | 0,8 | 0,3 | 0,4 |
| 11 | Aktienstraße, Daimlerstraße | freies Gelände | 530 | 0,9 | 0,2 | 0,6 | 0,4 | 0,4 | 0,5 |
| 12 | Freundhof | Waldgebiet | kein Verkehr | 0,9 | 3,1 | 0,8 | 1,2 | 0,9 | 1,4 |
| | g | Tagesmittel | | 1,1 | 0,7 | 0,8 | 0,7 | 0,6 | |

(See page 68 and 70 for key)

Key to Appendix 16 page 67 continued:

b) Designation of measuring points

c) Type of measuring points

d) Average vehicle density/h

e) mg of dust/$m^3$

f) Average

| | | |
|---|---|---|
| 1) | ..... | Densely populated area |
| 2) | ..... | Densely populated area |
| 3) | Railroad Station | Forecourt |
| 4) | ..Post Office | Main thoroughfare |
| 5) | ..... | Residential area |
| 6) | ..... | Residential area |
| 7) | Civil Eng. Office | In yard |
| 8) | ..... | Light residential area |
| 9) | Woods | No traffic |

g) Daily average

Key to Appendix 17 page 69:

a) MÜLHEIM (RUHR). Share of lead in suspended dust in percent.

b) Designation of measuring points

c) Type of measuring points

d) Average vehicle density/h

e) % of lead in dust

f) Average

| | | |
|---|---|---|
| 1) | ..... | Residential/Industrial area |
| 2) | ..... | Large crossing |

Key to Appendix 17 page 69 continued:

| | | | |
|---|---|---|---|
| 3) | ..... | Main thoroughfare | |
| 4) | At racetrack | Open, large terrain | |
| 5) | ..... | Residential area | |
| 6) | Center of town.. | Large square, many streets | |
| 7) | Railroad Station..<br>Station forecourt | Narrow place | |
| 8) | ..... | Large square, few houses | |
| 9) | ..... | Dwellings on both sides | |
| 10) | ..School | Residential area | Very slight |
| 11) | ..... | Open terrain | |
| 12) | ..... | Wooded area | No traffic |

g) Daily average

Key to Appendix 18 page 71:

a) DÜSSELDORF. Share of lead in suspended dust in percent

b) Designation of measuring points

c) Type of measuring points

d) Average vehicle density/h

e) % of lead in dust

f) Average

| | | |
|---|---|---|
| 1) | ..... | Large, open crossing |
| 2) | ..... | Narrow street, through traffic |
| 3) | ..Bus Terminal | Large square, center of town |
| 4) | Main Railroad Terminal | Large square, center of town |
| 5) | ..... | Large crossing, through traffic |
| 6) | ..... | Narrow street |

a **Düsseldorf.** Bleianteil im Schwebestaub in Prozent. **Anlage 18**

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/$h_a$ | e % Blei im Staub 21.9. 1965 | 14.10. 1965 | 28.10. 1965 | 11.11. 1965 | 25.11. 1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Hennekamp/Witzelstraße | große, offene Kreuzung | 1140 | -- | 0,4 | 0,6 | 1,0 | 0,5 | 0,6 |
| 2 | Werstener Kreuz | enge Straße, Durchgangsverkehr | 1000 | 0,2 | 0,4 | 0,6 | 1,4 | 0,7 | 0,7 |
| 3 | Graf-Adolf-Platz, Busbahnhof | weiter Platz, Zentrum | 1160 | 0,5 | 0,5 | 0,7 | 2,5 | 0,5 | 0,9 |
| 4 | Hauptbahnhof | weiter Platz, Zentrum | 100 | 1,1 | 0,4 | 0,7 | 1,2 | — | 0,8 |
| 5 | Grafenberger Allee/ Lindemannstraße | große Kreuzung, Durchgangsverkehr | 1030 | 0,3 | — | 0,5 | 1,7 | 0,5 | 0,7 |
| 6 | Rather Kreuzweg/ Westfalenstraße | enge Straße | 610 | 1,3 | 0,3 | 0,3 | 0,6 | 0,2 | 0,5 |
| 7 | Ulmenstraße/Glockenstraße | enge Straße | 480 | 0,8 | 0,5 | 0,5 | 0,9 | 0,6 | 0,7 |
| 8 | Oberkasseler Brücke | sehr verkehrsreich | 1690 | 0,7 | 0,5 | 0,5 | 0,5 | 0,6 | 0,6 |
| 9 | Stockumer Kirchstraße/ Kaiserswerther Straße | weite, offene Kreuzung | 360 | 0,7 | 0,4 | 0,3 | 0,6 | 0,6 | 0,5 |
| 10 | Rennbahngelände | offenes, begrüntes Feld | kein Verkehr | 1,0 | 0,4 | — | — | 0,3 | 0,5 |
| | g Tagesmittel | | | 0,7 | 0,4 | 0,5 | 1,2 | 0,5 | |

(See page 70 for key)

(continued on page 72)

Key to Appendix 18 page 71 continued:

| | | |
|---|---|---|
| 7) | ..... | Narrow street |
| 8) | ...Bridge | Much traffic |
| 9) | ..... | Broad, open crossing |
| 10) | Racetrack terrain | Open, grass-covered field No traffic |
| g) | Daily average | |

Key to Appendix 19 page 73:

a) NEUß ON THE RHEIN. Share of lead in suspended dust in percent

b) Designation of measuring points

c) Type of measuring points

d) Average vehicle density/h

e) % of lead in dust

f) Average

| | | |
|---|---|---|
| 1) | ..... | Main street, residential area |
| 2) | ..... | Thoroughfare |
| 3) | ..(City Hall) | One-way street, lively traffic |
| 4) | Harbor... | Industrial area |
| 5) | ..... | Divided road |
| 6) | ..... | Main traffic junction |
| 7) | ..... | Heavy frequency |
| 8) | ..... | Residential area, park |
| 9) | ..... | Large crossing, gardens |
| 10) | Board of Health.. | Open square, residential area--Slight traffic |
| g) | Daily average | |

a Neuß am Rhein. Bleianteil in Schwebestaub in Prozent. Anlage 19

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e % Blei im Staub 15.9.1965 | 12.10.1965 | 26.10.1965 | 9.11.1965 | 23.11.1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Reuschenberg, Bergheimer Straße 481 | Hauptstraße, Wohngebiet | 360 | 0,7 | 0,7 | 0,3 | 0,3 | — | 0,5 |
| 2 | Obertor 19 | Durchgangsstraße | 290 | 1,0 | 0,3 | 0,4 | 0,2 | 0,4 | 0,5 |
| 3 | Markt (Rathaus) | Einbahnstraße, reger Verkehr | 440 | 1,1 | 0,7 | 0,4 | 0,4 | 0,4 | 0,6 |
| 4 | Hafen, Hammer Landstraße | Industriegebiet | 280 | 1,0 | 0,2 | 0,5 | 0,4 | 0,7 | 0,6 |
| 5 | Drususallee, Kindergarten | Fahrbahn getrennt | 230 | 1,3 | 0,1 | 0,3 | 0,2 | 0,3 | 0,4 |
| 6 | Krefelder Straße/ Theodor-Heuss-Platz | Hauptverkehrspunkt | 670 | 0,9 | 0,1 | 0,8 | 0,8 | 0,5 | 0,6 |
| 7 | Kaarster Straße/ Gladbacher Straße | starke Frequenz | 430 | 0,9 | 0,5 | 0,4 | 0,4 | 0,4 | 0,5 |
| 8 | Berliner Platz/ Further Straße | Wohngebiet, Parkplatz | 380 | 0,8 | 0,3 | 0,8 | 0,4 | 0,6 | 0,6 |
| 9 | Friedrich-Ebert-Platz | große Kreuzung, Grünanlage | 380 | 1,1 | 0,6 | 0,5 | 0,5 | — | 0,7 |
| 10 | Gesundheitsamt, Carossastraße | offener Platz, Wohngebiet | geringer Verkehr | 1,5 | 0,2 | 0,3 | 0,4 | 0,7 | 0,6 |
| | g | Tagesmittel | | 1,0 | 0,4 | 0,5 | 0,4 | 0,5 | |

(See page 72 for key)

Key to Appendix 20 page 75:

a) DUISBURG. Share of lead in suspended dust in percent

b) Designation of measuring points

c) Type of measuring points

d) Average vehicle density/h

e) % of lead in dust

f) Average

| | | | |
|---|---|---|---|
| 1) | ..... | Industrial area | |
| 2) | ..... | Large mixed area | |
| 3) | ..... | Residential area, large crossing | |
| 4) | ..... | Open | |
| 5) | ..... | Large crossing, open | |
| 6) | ..... | Residential area | |
| 7) | ..... | Large crossing, lively traffic | |
| 8) | ..... | Center of town | |
| 9) | ..... | Residential area at park | |
| 10) | .. Beach | Edge of municipal park | Hardly any |

g) Daily average

Key to Appendix 21 page 76:

a) WUPPERTAL. Share of lead in suspended dust in percent

b) Designation of measuring points

c) Type of measuring points

d) Average vehicle density/h

e) % of lead in dust

f) Average

a **Duisburg.** Bleianteil im Schwebestaub in Prozent. **Anlage 20**

| Nr. | Meßstellenbezeichnung b | Art der Meßstelle c | mittlere Fahrzeugdichte/h d | e % Blei im Staub 23.9. 1965 | 13.10. 1965 | 27.10. 1965 | 10.11. 1965 | 24.11. 1965 | Mittel f |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Ehingerstraße/ Steinbrinkstraße | Industriegegend | 90 | 0,6 | 0,3 | 0,5 | 0,5 | 1,3 | 0,6 |
| 2 | Düsseldorfer Straße/ Kulturstraße | weiträumig gemischte Gegend | 1290 | 0,8 | 0,5 | 0,4 | 0,5 | 0,4 | 0,5 |
| 3 | Alt Hamborn, Duisburger Straße/Alleestraße | Wohngebiet, große Straßenkreuzung | 930 | 1,0 | 0,8 | — | — | — | 0,9 |
| 4 | Sternbuschweg/Hertzstraße | offen | 340 | 0,7 | 0,7 | 0,5 | 0,3 | 0,2 | 0,5 |
| 5 | Sternbuschweg/ Mülheimer Straße | große Straßenkreuzung, offen | 890 | 0,8 | 0,8 | 0,5 | 0,7 | 1,1 | 0,8 |
| 6 | Nordtunnel/Mühlenstraße | Wohngebiet | 260 | 0,7 | 1,1 | 1,0 | 0,4 | 0,7 | 0,8 |
| 7 | Rheinhauser Straße/ Heerstraße | große Kreuzung, reger Verkehr | 1060 | 0,4 | 0,5 | 0,6 | 0,5 | 2,5 | 0,9 |
| 8 | Königstraße/ Düsseldorfer Straße | Stadtzentrum | 680 | 1,3 | 0,8 | 0,8 | 0,6 | 1,2 | 0,9 |
| 9 | Bürgermeister-Pütz-Straße/ Gabelsberger Straße | Wohnviertel am Park | 280 | 1,5 | 0,8 | 0,5 | 0,7 | — | 0,9 |
| 10 | Wedau, Strandbad | Stadtwaldrand | kaum | 0,8 | 0,8 | 0,4 | 0,2 | 0,3 | 0,5 |
| | g | Tagesmittel | | 0,9 | 0,7 | 0,6 | 0,5 | 1,0 | |

(See page 74 for key)

Wuppertal. Bleianteil im Schwebestaub in Prozent. Anlage 21

| Nr. | Meßstellenbezeichnung | Art der Meßstelle | mittlere Fahrzeugdichte/h | % Blei im Staub | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 16. 9. 1965 | 7. 10. 1965 | 25. 10. 1965 | 18. 11. 1965 | 15. 12. 1965 | Mittel |
| 1 | Friedrich-Ebert-Straße/ Varresbecker Straße | dicht besiedeltes Gebiet | 820 | 0,4 | 0,6 | 0,3 | 1,5 | 0,2 | 0,6 |
| 2 | Neumarkt | dicht besiedeltes Gebiet | 1050 | 0,3 | 0,4 | 0,7 | 1,1 | 0,6 | 0,6 |
| 3 | Bahnhof | Vorplatz | 700 | 0,6 | 0,8 | 0,3 | 1,5 | 0,4 | 0,7 |
| 4 | Friedrich-Engels-Allee, Post | Hauptverkehrsstraße | 590 | 0,4 | 0,3 | 0,3 | 1,1 | 0,5 | 0,5 |
| 5 | Uellendahler Straße/ Wiesenstraße | Wohngegend | 950 | 0,4 | 1,1 | 1,2 | 2,8 | 0,8 | 1,3 |
| 6 | Schönebecker Straße/ Sandstraße | Wohngegend | 490 | 0,6 | 0,3 | 0,3 | 0,7 | 0,2 | 0,4 |
| 7 | Klingelholl, Tiefbauamt | im Hof | 310 | 0,4 | 0,5 | 0,4 | 1,0 | 0,3 | 0,5 |
| 8 | Langenfelder Straße/ Rauentaler Bergstraße | lichtes Wohngebiet | 240 | 0,2 | 0,3 | 0,2 | 4,9 | 0,2 | 1,2 |
| 9 | Burgholz | | kein Verkehr | 0,6 | 0,4 | 0,2 | 0,4 | 0,4 | 0,4 |
| | | Tagesmittel | | 0,4 | 0,5 | 0,4 | 1,2 | 0,4 | |

(See page 74 ant. // for key)

Key to Appendix 21 page 76 continued:

| | | |
|---|---|---|
| 1) | ..... | Densely settled area |
| 2) | ..... | Densely settled area |
| 3) | Terminal | Forecourt |
| 4) | ..... | Main thoroughfare |
| 5) | ..... | Residential area |
| 6) | ..... | Residential area |
| 7) | ..Civil Eng. Office | In yard |
| 8) | ..... | Light residential area |
| 9) | Woods | No traffic |
| 5) | Daily average | |

Key to Appendix 22 page 78:

a) Frequency distribution of lead concentration

b) Concentration ug of Pb per $m^3$

c) Number

d) Sum

e) Cumulative frequency - %

f) To 1

Key to Appendix 23 page 79:

a) Median and 95% value in ug of $Pb/m^3$

Anlage 22

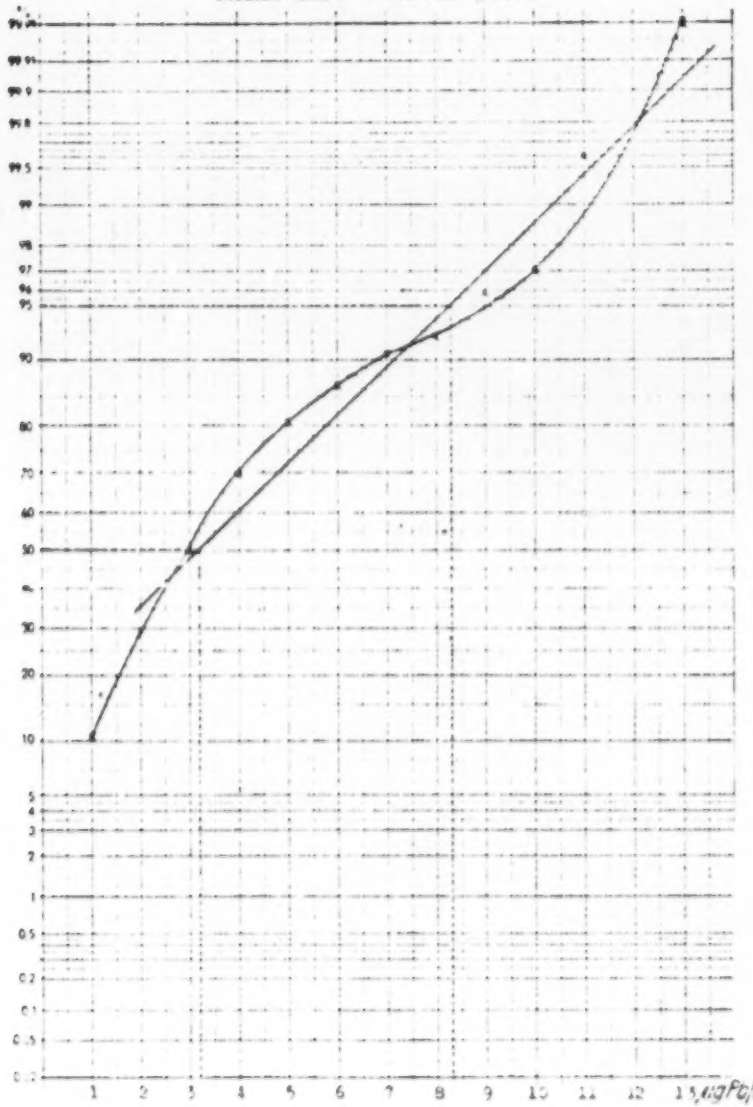
a Häufigkeitsverteilung der Bleikonzentration.

| Konzentration µg Pb je m³ b | c Anzahl: Mülheim | Düsseldorf | Neuß | Wuppertal | Duisburg | Summe d | % | Summenhäufigkeits-% e |
|---|---|---|---|---|---|---|---|---|
| f bis 1,0 | 4 | 4 | 5 | 8 | 4 | 25 | 10,2 | 10,2 |
| 1,1— 2,0 | 13 | 8 | 11 | 5 | 10 | 47 | 19,2 | 29,4 |
| 2,1— 3,0 | 6 | 11 | 8 | 13 | 12 | 50 | 20,4 | 49,8 |
| 3,1— 4,0 | 14 | 11 | 6 | 9 | 8 | 48 | 19,6 | 69,4 |
| 4,1— 5,0 | 9 | 8 | 7 | 3 | 1 | 28 | 11,4 | 80,8 |
| 5,1— 6,0 | 3 | 3 | 5 | 1 | 2 | 14 | 5,7 | 86,5 |
| 6,1— 7,0 | 2 | | 2 | 1 | 5 | 10 | 4,1 | 90,6 |
| 7,1— 8,0 | 1 | 1 | 1 | 1 | 1 | 5 | 2,0 | 92,6 |
| 8,1— 9,0 | 3 | | 2 | 2 | 1 | 8 | 3,3 | 95,9 |
| 9,1—10,0 | 1 | | | 2 | | 3 | 1,2 | 97,1 |
| 10,1—11,0 | 4 | | | | 2 | 6 | 2,5 | 99,6 |
| 11,1—12,0 | | | | | | | | |
| 12,1—13 | | | 1 | | | 1 | | 100,0 |
| | 60 | 46 | 48 | 45 | 46 | 245 | | |

(See page 77 for key)

Anlage 23

a Median- und 95 %-Wert in µg Pb/m³




(See page 77 for key)

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